YEAR TWO - ANNUAL REPORT 2005-06

FLOATING MARSH CREATION DEMONSTRATION PROJECT (LA-05)

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INTRODUCTION

The Floating Marsh Creation Demonstration Project (LA-05) was approved in January 2003 as part of PPL 12. The Federal Sponsor is U.S.D.A. Natural Resources Conservation Service and the non-Federal Sponsor is Louisiana Department of Natural Resources. The objective of the Floating Marsh Creation Demonstration Project is to develop methods for restoration of open areas within thin and deteriorated marsh mats that once supported thick-mat maidencane (*Panicum hemitomon*) marsh and other fresh water areas where establishment of maidencane marsh is desired. The demonstration project consists of two phases. The first phase, which is being performed at LSU and UNO, is the development of artificial floating-marsh systems (AFS) and consists of two components. The first component is development of a floating system which would provide the structure to keep the substrate and vegetation in place and would provide the buoyancy during the period in which *Panicum hemitomon* plants become established. For this component, structures using a variety of mat materials, support structures, and plant materials are being evaluated. The second component of the first phase consists of efforts to understand the plant response to nutrients, flooding, and substrate in order to develop methods to maximize the establishment and growth of *P. hemitomon* in AFS.

The second phase of the demonstration project consists of field testing of the selected designs in a marsh setting, initiated in year two of the project. Based on the structural integrity, buoyancy, and growth response results from the first phase investigations, the selected designs were brought forward for deployment at the Mandalay National Wildlife Refuge in Terrebonne Parish, Louisiana.

In this annual report we provide a narrative summary by task of activities and accomplishments through year two of the floating marsh creation demonstration project.

Background

Land loss in coastal Louisiana has been well documented and related to a variety of causes (Craig et al. 1979, Gagliano et al. 1981, Sasser et al. 1986, Evers et al. 1992, Britsch and Dunbar 1993). This loss covers all marsh types, including freshwater floating marshes. Even though the remaining marshes in the upper part of the coast have remained fresh since they were first mapped by O'Neil (1949), significant areas of marsh have converted to open water, and vegetation associations have changed from thick-mat maidencane (*Panicum hemitomon*) dominated marsh to thin-mat spikerush (*Eleocharis baldwinii*) dominated marsh (Visser et al. 1999). Visser et al. (1999) identified the following potential causes for the dramatic change in fresh marsh vegetation and land loss: grazing by nutria, increased water levels, hydrologic modifications, and eutrophication. Sasser et al. (2004) show that grazing by nutria may be the most important of these factors in freshwater marshes. Although the effect of nutria grazing on maidencane marshes has not yet been documented, nutria grazing helps prevent the re-establishment of maidencane in spikerush marshes (Visser et al. 2001). In addition, recent research has shown that maidencane grows well in the spikerush floating marsh with or without nutrient enhancement when protected from grazing (Sasser et al. 2004). This indicates that no nutrient limitation exists in the maidencane marsh areas that have converted to spikerush marsh and open water.

The belowground structure of *P. hemitomon* is characterized by extensive root and rhizome allocation that results in an organic root mat that is very fibrous and buoyant. *P. hemitomon*'s extensive network of fibrous roots and rhizomes is crucial for forming well-integrated floating marsh mats. The ability of other co-dominant or subordinate species (e.g., *Sagittaria lancifolia*, *Eleocharis baldwinii*) to form this type of highly-buoyant floating root mat in the absence of *P. hemitomon* seems improbable based on their respective belowground morphologies and general architecture. Therefore, *P. hemitomon* probably plays a key role in the successful formation and sustainability of healthy (thick mat) freshwater floating marshes (Sasser 1994, Holm et al. 2000), and will be the primary plant species utilized in this project.

SUMMARY OF ACTIVITIES AND ACCOMPLISHMENTS BY TASK

Task 1 – AgCenter Program Development

The LSU AgCenter provides project supervision to develop, manage, and oversee implementation of the LA-05 Floating Marsh Creation Demonstration Project. Over the period of year two of the project, from July 1, 2005 through June 30, 2006, the project has been successfully implemented with major progress achieved over the period. Updates to DNR were provided in progress reports that were prepared and submitted to the DNR project manager. Additional information was provided as requested. A site visit was conducted in spring 2006 to the field deployment site at the Mandalay National Wildlife Refuge for state and federal agency participants to see ongoing project work in the field deployment phase. This site visit was an opportunity for participants to view the project work underway, hear descriptions of the status of the ongoing work, and have ample opportunity for questions and discussion regarding the demonstration project work.

Task 2 – Comprehensive Project Plan Development

Development of the Comprehensive Project Plan related to Task 2 of the Interagency Agreement was completed during the fall of 2004. The Plan was submitted to the DNR project manager in draft form, and revised to incorporate comments from DNR and NRCS reviewers. The Draft Final Plan was submitted and subsequently revised to incorporate all comments provided by the DNR and NRCS reviewers, and the revised report was delivered in November 2004 as the Final Comprehensive Project Plan.

Task 3 – Comprehensive Monitoring Plan Development

After completion and acceptance of the Comprehensive Monitoring Plan, work on the associated Draft Comprehensive Monitoring Plan related to Task 3 of the Interagency Agreement was completed and submitted to DNR in December 2004. After receiving and incorporating review comments, the Final Comprehensive Monitoring Plan was submitted to DNR in June 2005.

Task 4 – Landrights Acquisition

Early in the first year of the project, we began the process of acquiring landrights from a cooperating landowner, as related to Task 4 of the Interagency Agreement. Degraded freshwater marsh areas within the Mandalay National Wildlife Refuge in Terrebonne Parish, LA were determined to be desirable for the Field Testing Phase deployment of selected artificial floating systems into outfield marsh sites. Concurrence was obtained from the CWPPRA Environmental and Engineering working groups for the selection of this site.

We initiated discussions regarding landrights acquisition in fall 2004 with Mr. Paul Yakupzack, Refuge Manger, Mandalay/Bayou Teche NWR Complex. During that period we visited the refuge and looked at and identified potential field sites with Mr. Yakupzack. Subsequently we submitted a proposal to DNR for their review and concurrence that the second phase of the Demonstration Project be located on the Mandalay National Wildlife Refuge. We coordinated our landrights acquisition request from the LSU AgCenter with Ms. Helen Hoffpauir, DNR Land Section, before submitting the request to Mr. Paul Yakupzack, Refuge Manager, Mandalay/Bayou Teche NWR Complex. Subsequently, Mr. Yakupzack provided a Special Use Permit for the project site to locate on the Mandalay Refuge for the term of the demonstration project. The Special Use Permit has been approved and signed by officials of both the LSU AgCenter and the Mandalay National Wildlife Refuge.

Task 5 – Environmental Compliance

Work was completed during this period on the Environmental Compliance requirements related to Task 5 of the Interagency Agreement. We completed work on the Draft “Project Plan and Environmental Assessment for the Floating Marsh Creation Demonstration Project (LA-05)” and submitted it to DNR for review and comments in February 2005. A Final Draft EA was submitted to DNR in May 2005. During the fall 2005 we received a general permit from USACE for the project work, in response to our previous submission of the Joint Permit Application to DNR and USACOE. The final Environmental Assessment document was published and no additional comments were received, therefore the Environmental Assessment is completed.

Task 6 – Year 1 Mat Development and Selection

The timeline for completion of phase one AFS development and selection related to Task 6 was extended through the end of the 2005 growing season (DNR Interagency Agreement No.2511-05-01, OCR No. 435-500537, Amendment No. 01), in order to provide plant material in the artificial floating system structures a full growing season to grow, expand, and develop the below-ground plant material into a functional mat. During this period the Louisiana coast was severely impacted by Hurricanes Katrina and Rita, affecting some of our project activities as indicated in the discussion below.

LSU AgCenter Greenhouse and Research Pond Work

The demonstration project work underway at the LSU AgCenter facilities in Baton Rouge received only minor damage from Hurricane Katrina, and was completed in fall 2005. This work was on the project component involving overall development of Artifical Floating System (AFS) designs that would provide the structure, substrate, vegetation, and the buoyancy necessary for establishment and growth of *Panicum hemitomon.* We evaluated multiple designs at the LSU AgCenter Research Ponds, and submitted our recommendations on the AFS designs that had performed best during the evaluation, as a requirement related to Task 6 of the Interagency Agreement. DNR provided a letter of concurrence dated March 14, 2006 to the recommended AFS designs for deployment to the Mandalay National Wildlife refuge in Terrebonne Parish, Louisiana.

Following is a summary of the activities at the LSU AgCenter research facilities related to the Artifical Floating System designs development.

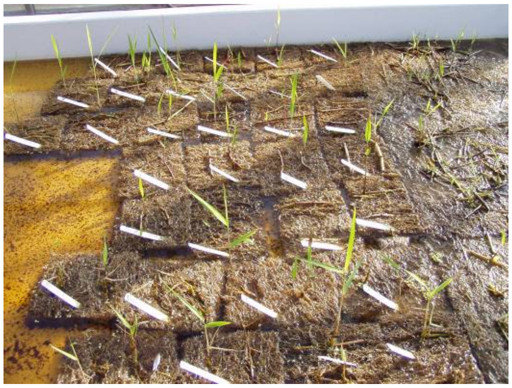
Artificial Floating Marsh Systems

Testing of Artificial Floating Marsh Systems (August 22, 2005).

We developed 27 AFS designs that were tested in an outdoor laboratory setting with *Panicum hemitomon* established from nursery stock and/or plugs harvested from healthy marshes (Appendix A). Dimensions ranged from 1-10.4 m^2 (10.8 to 112 ft^2), with at least three replicates of each. Frames were constructed using pine two-by-fours, PVC, Styrofoam, cedar planks, bamboo, or combinations of these materials (Table 1). Mat materials tested included rope, jute netting, straw-coconut, burlap, coconut, birch, as well as hydroponic growth on chicken wire mats. Some of these mats were augmented with hardwood mulch and a peat-bagasse mixture to provide additional substrate. Plants were established using plugs harvested from donor marshes, fragments (*P. hemitomon* pieces containing both rhizome and stem material), *P. hemitomon* rhizomes, or *P. hemitomon* stems (Table 1).

Construction was designed such that each AFS can be put together in the field. Each design incorporated an anchoring system to minimize horizontal movement, while not hindering vertical movement of the AFS. The AFSs were designed to maintain sufficient structural integrity until the established *P. hemitomon* mat becomes self sustainable. The fabrication of each design is such that multiple units can be attached to one another to create larger areas of floating *P. hemitomon* marsh for field testing. AFS designs 1 through 12 were deployed in the summer of 2004, designs 13 through 24 were deployed in the spring of 2005, and designs 25 through 27 were deployed in summer 2005. Fences were added to AFS designs 5, 6, 7, and 12 in October 2004 to eliminate grazing. AFS 3 was fenced in March 2005 and the other fenced structures were planted at this time. AFS designs 15 through 27 were fenced before deployment in the pond. Buoyancy, structural integrity, and plant cover of each AFS were assessed several times a month.

Plant establishment



Testing of Vegetative Establishment

In addition to determining which AFS would be successful in keeping plant material buoyant in a larger scale application for initiating floating marsh development, we also tested which types of plant material could be used to establish *P. hemitomon* under greenhouse conditions. We tested the application of using *P. hemitomon* fragments, as well as rhizome or stem material. Furthermore, we tested for the smallest portion to consistently result in the growth of new plants. Sizes used included no node, one node, and two node pieces.

Fragment, stem and rhizome pieces were placed on individual squares of coconut fiber mat material. These mats were monitored to determine the number of shoots produced by each different type and size of plant material.

Performance

Several designs performed well, while some structures lost buoyancy and/or suffered from mat disintegration. We will describe the failures first, then those structures that have performed well. The first AFS that failed was AFS 4. The Styrofoam billets became a favorite spot for nutria and muskrat and these animals damaged the burlap mat. These structures were removed from the ponds in October 2004. The second failing design was AFS 2. The jute mat used in this design disintegrated within a few months after deployment, and one of the structures lost buoyancy as the pine frame became water logged. This design was removed from the pond in early March 2005. AFS 8 submerged in November 2004, after submergence and eventually completely disintegrated. Four of the five replicates of AFS 10 lost buoyancy as both the coconut mat and the pine frame became waterlogged. These structures were removed from the ponds between November 2004 and March 2005. All structures were heavily grazed by both nutria and muskrat, and it became apparent that these grazers needed to be excluded from the structures. Exclusion was not possible for AFS designs 1 and 11, which were heavily grazed and in addition

Table 1. Overview of the 27 Artificial Floating Systems developed during 2004-05.

Fr a m					
1	10 x 10	pine	rope	none	large plugs
2	10 x 10	pine	jute	hardwood mulch	plugs
3	4 x 10	PVC & pine	straw-coconut	hardwood mulch	plugs
4	10 x 10	Styrofoam & pine	burlap	hardwood mulch	plugs
5	10 x 10	PVC	coconut	hardwood mulch	A & C plugs; B fragments
6	4 x 4	pine	birch	hardwood mulch	plugs
7	4 x 4	PVC	coconut	hardwood mulch	plugs
8	4 x 4	none	burlap	water-hyacinth	plugs
9	4 x 4	pine & Styrofoam	coconut	hardwood mulch	plugs
10	4 x 4	pine	coconut	hardwood mulch	plugs
11	4 x 4	pine	rope	none	plugs
12	4 x 4	pine	chicken-wire	none	plugs
13	4 x 4	PVC	chicken-wire	none	plugs
14	4 x 4	PVC	chicken-wire	peat & bagasse	fragments
15	4 x 4	cedar lattice	coconut	none	plugs
16	4 x 4	cedar lattice	coconut	none	plugs
17	4 x 4	cedar lattice	none	none	plugs
18	4 x 4	cedar lattice	coconut	none	plugs
19	4 x 4	pine	chicken-wire	none	A & C fragments; B plugs
20	4 x 4	pine	birch	peat & bagasse	A & B plugs; C fragments
21	4 x 4	pine	coconut	peat & bagasse	A & B plugs; C fragments
22	4 x 4	bamboo	chicken-wire	none	A fragments; B & C plugs; D, E, & F rhizomes; G, H, I stems
23	4 x 4	bamboo	birch	peat & bagasse	B & C fragments; A plugs
24	4 x 4	bamboo	coconut	peat & bagasse	A & B fragments; C plugs; D, E, & F rhizomes; G, H, I stems
25	4 x 4	PVC	none	styrofoam	peat pots
26	4 x 10	PVC	chicken-wire	peat	peat pots
27	4 x 10	PVC	chicken-wire	none	fragments

the burlap bags in these designs and some of the ropes had deteriorated. Therefore, AFS 1 and 11 were removed from the ponds in early March 2005. AFS 9 remained buoyant until grazers damaged the fasteners that attached the Styrofoam, so these structures were also removed in early March 2005. Both the cedar lattice structures (AFS 15, 16, 17, and 18) and the wood gabion structures (AFS 19, 20, and 21) lost buoyancy within several weeks after deployment. Buoyancy was increased by adding bamboo sections to these structures.

Two of the original pine frames (AFS 6 and 12) were fenced with vinyl coated chicken-wire (crab pot wire) in October 2004, which added a significant amount of weight and required the addition of Styrofoam to increase the buoyancy of these structures when they were fenced. The designs that incorporated either PVC (AFS 3, 5, and 7) or bamboo (AFS 22, 23, and 24) were successful in maintaining buoyancy on their own.

We present the analysis of the *P. hemitomon* cover and species diversity as observed on August 17, 2005 (the last observation before the hurricanes disturbed several of the structures) using only those structures deployed throughout the 2005 growing season (AFS 3, 6, 7, 12, and 15 through 25). When grouped by frame type, the cedar lattice designs tended to have the greatest cover of *P. hemitomon* (Figure 1). This may be due to the partial submergence of these structures for two weeks in early May. We observed that during submergence *P. hemitomon* stems elongated, and cover of competing species decreased. However, it should be noted that these structures also had the highest cover immediately after planting (28%). The other structures had an average initial cover of 10%. A few of the pine wood structures submerged for a week in mid-April, but no elongation effects were observed in these structures.

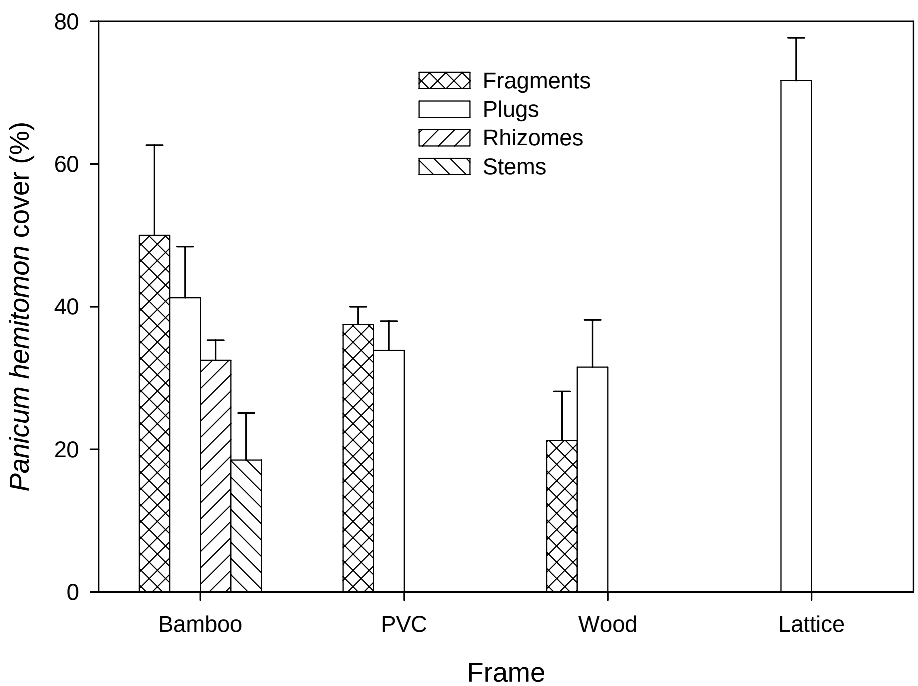


Figure 1. Effect of frame type on *P. hemitomon* cover on August 22, 2005. Only the bamboo frames were planted with stems and rhizomes.

By August 2005, a noticeable difference in species diversity was observed among the different frames (Figure 2). Structures that were planted with marsh plugs had a significantly higher number of species than those planted with fragments, rhizomes, or stems (Figure 2). This is not surprising, since the plugs contained multiple species at the time of planting and species could only establish on the other structures from local seed sources. Of the structures planted with plugs, the more buoyant frames (PVC and bamboo) had higher species diversity than the less buoyant structure frames.

Panicum. hemitomon cover was highest when plant establishment occurred with plugs and the structure contained either coconut, chicken wire or no mat (Figure 3). The relatively low cover on the straw-coconut mat, may be the result of the lower planting density on these mats (initial cover 5%). The lower performance of plugs on birch mats was due to the establishment of *Ludwigia* sp. which outcompeted *P. hemitomon* late in the growing season as well as reduced the buoyancy of these structures. When established from fragments, the highest *P. hemitomon* cover occurred on structures with birch mats, followed by coconut mats, and chicken wire mats (Figure 3). Establishment from rhizomes resulted in similar cover to those established from fragments irrespective of mat type. On the coconut mat, establishment from stems resulted in the same *P. hemitomon* cover reached by fragments or rhizomes. In contrast, establishment from stems failed while grown under hydroponic conditions on chicken wire mats.

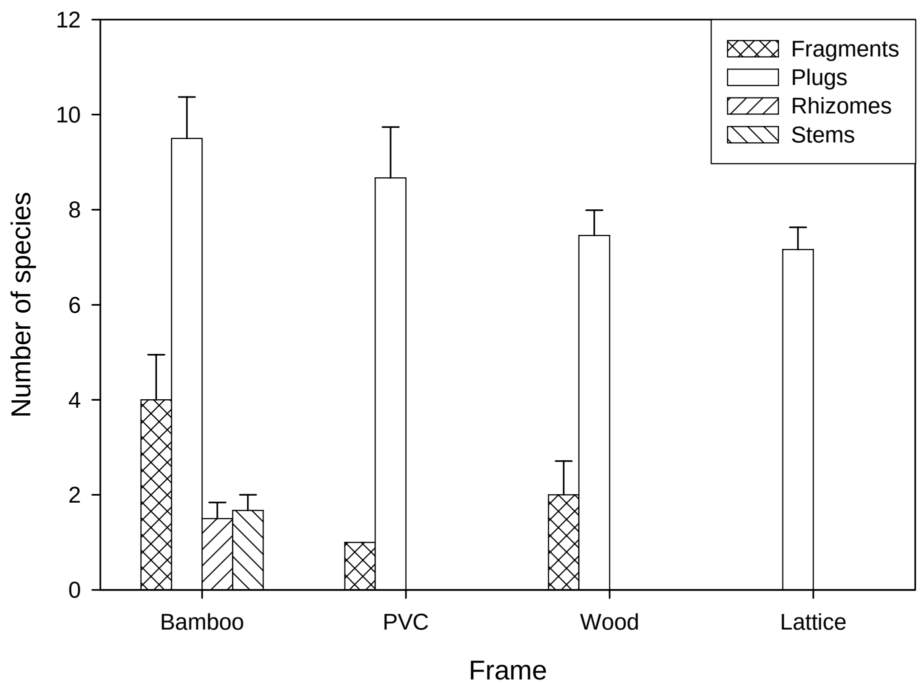


Figure 2. Effect of frame type on the number of species on August 22, 2005. Only the bamboo frames were planted with stems and rhizomes.

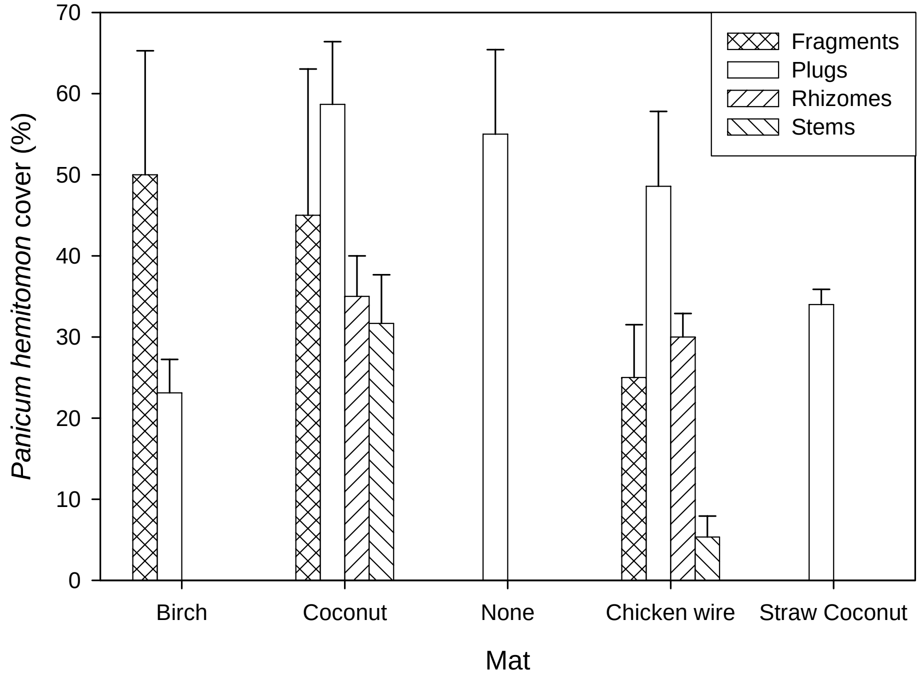


Figure 3. Effect of mat type on *P. hemitomon* cover on August 22, 2005. Only the coconut and chicken wire mats were planted with stems and rhizomes.

The poor performance of *P. hemitomon* on chicken wire mats, when established from sources other than plugs, may have resulted from our inability to fertilize these structures in April. Plugs were fertilized and in addition plugs provide their own substrate. We fertilized the chicken-wire mat structures (AFS 19 and 22) with Osmocote® suspended in nylon bags at the end of June 2005, however the stems did not catch up to the growth of fragments and rhizomes planted structures.

Substrate had some effects on *P. hemitomon* performance (Figure 4). Plugs performed best without any substrate, but this may be driven by the denser planting of the lattice designs (AFS 15, 16, 17, and 18), which make up the majority of the structures without substrate. The other structures without substrate are AFS 12, 19, and 22. The performance of plugs was similar for hardwood mulch and peat-bagasse substrates. When established from fragments, rhizomes, and stems, cover was larger on the peat-bagasse substrate than when grown under hydroponic condition. This is probably related to our inability to properly fertilize the hydroponic structures early in the growing season.

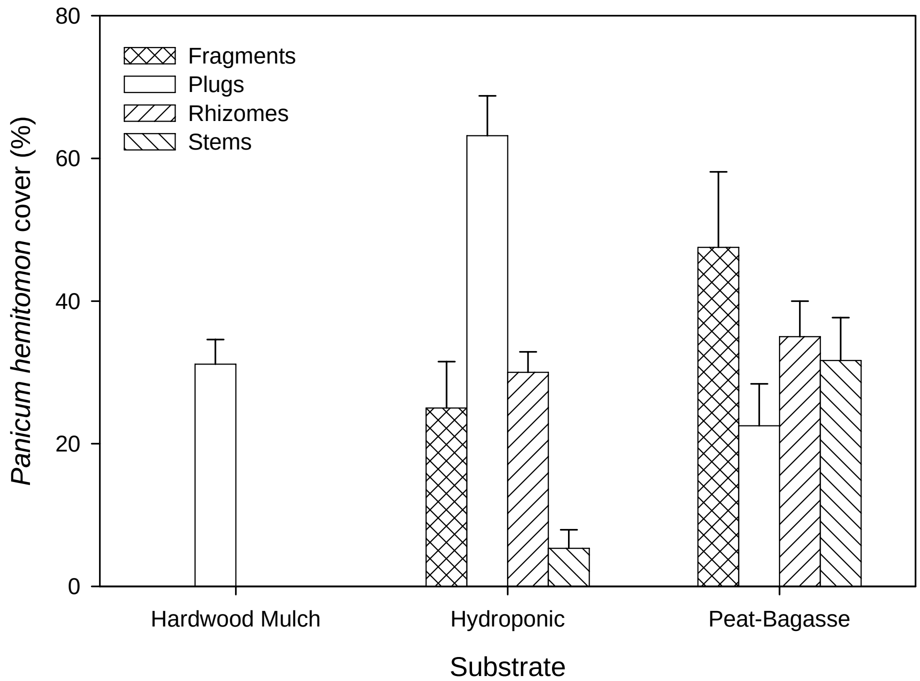


Figure 4. Effect of substrate type on *P. hemitomon* cover on August 22, 2005. Only the peat-bagasse treatments and the treatments without substrate were planted with stems and rhizomes.

The substrate also affected species diversity (Figure 5). When established from plugs, highest species diversity occurred on the hard wood mulch, followed by hydroponic and the lowest diversity on peat-bagasse. In contrast, when established from fragments, stems, or rhizomes no other species besides *P. hemitomon* established under hydroponic conditions, with a few more species establishing from seed when a substrate was available.

Plant Establishment

We found highest shoot production in the green house when using fragments compared to rhizome and stem material. Almost all fragments produced shoots, while nearly 75% of rhizomes with either 1 or 2 nodes yielded shoots after 28 days (Figure 6). Shoot production from stem pieces was lowest, with 50% of stems producing shoots after 28 days.

We also evaluated the effect of fertilization on shoot production of *P. hemitomon* stem and rhizome material (Figure 7). In this trial, we used randomly chopped stem or rhizome material, with variable number of nodes per piece. We spread those pieces evenly across six 2-inch thick coconut fiber squares that were saturated with water. Half of the coconut fiber squares were fertilized and the other half were left unfertilized. In the unfertilized treatment, rhizome pieces outperformed stem pieces throughout the experiment (Figure 7).

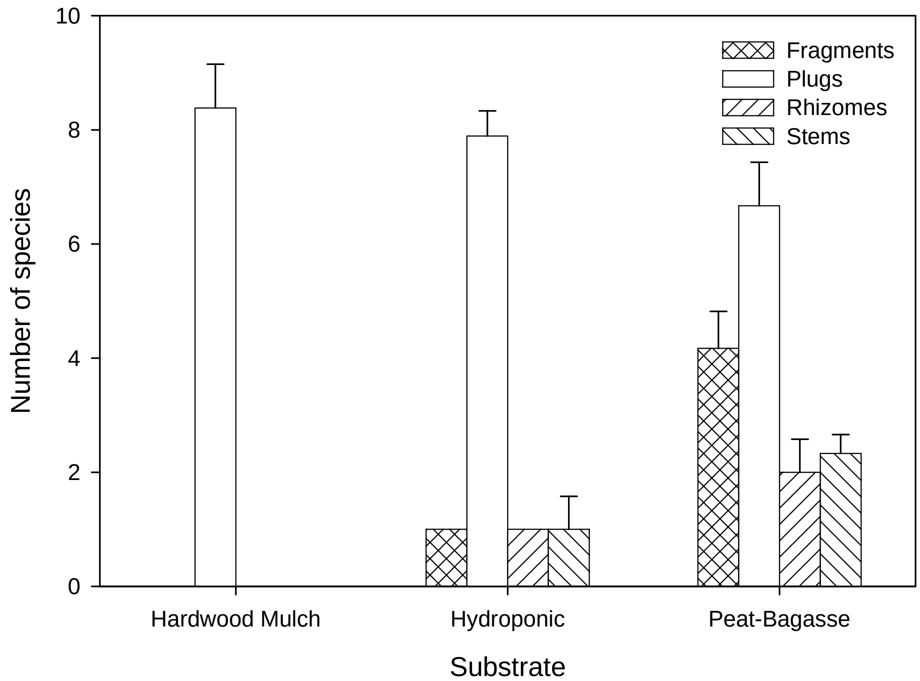


Figure 5. Effect of substrate type on the number of species on August 22, 2005. Only the peat-bagasse treatments and the treatments without substrate were planted with stems and rhizomes.

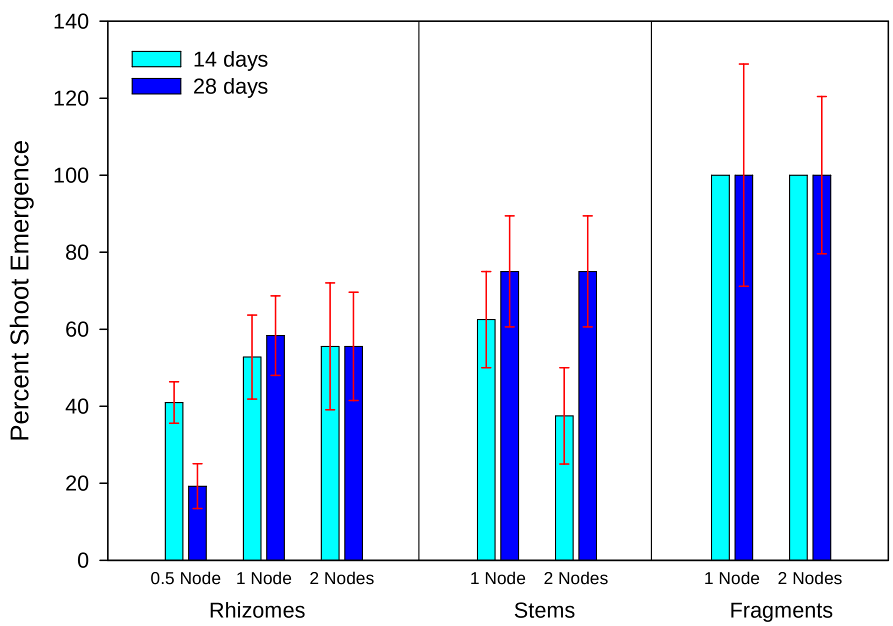


Figure 6. Effect of plant material on shoot development.

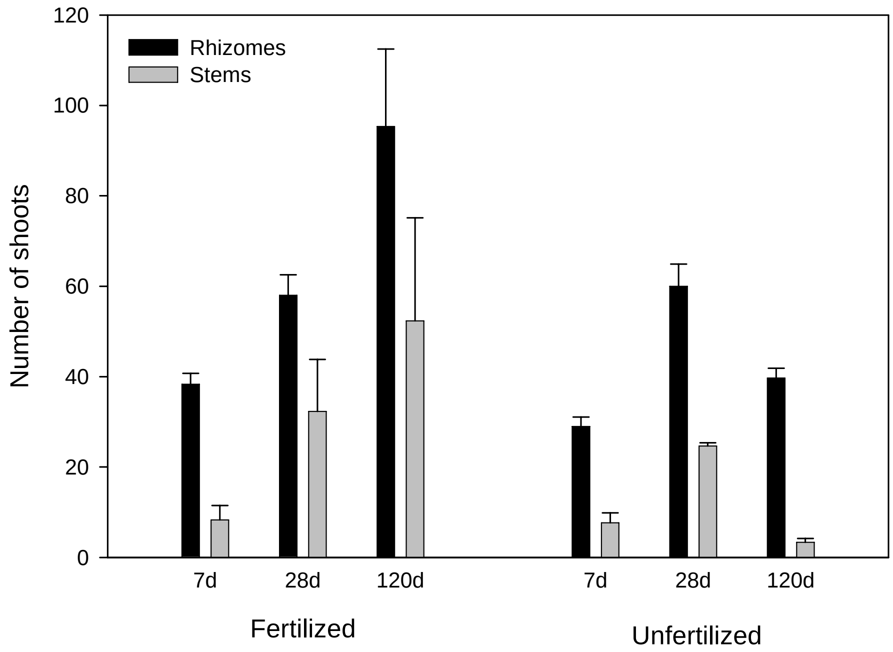


Figure 7. Effect of plant material and fertilization on shoot development.

However, we found that the addition of fertilizer greatly improved shoot production in both stem pieces and rhizomes. Thus, using randomly chopped stem or rhizome material could be a viable way to propagate *P. hemitomon*, and nutrient availability in the marsh water should improve shoot production.

Root mat formation from discarded stems

In the process of growing plants for the field deployment phase of the project, plants were regularly cut to promote root development. Cut stems were left in trays with water and consistently developed extensive root mats. This observation combined with the shoot formation experiment as well as the success of growing *P. hemitomon* from stem pieces in the floating structures provided information to conclude that plant establishment from stem fragments is an option that should be tested under field conditions.

Optimization of Plant Response

The greenhouse work at UNO by Dr. Mark Hester, Ellery Mayence and associates on plant responses of *Panicum hemitomon* to variable flooding, nutrient, and substrate effects was severely impacted by Hurricane Katrina in August 2005. As a result of the flooding and wind damage from Katrina, and the resulting closure of UNO for the fall, the experiments that were salvageable were transferred to LSU in Baton Rouge for processing during fall 2005. The following information was provided by Dr. Hester and Mr. Mayence relative to the status of their work at UNO that is completed or continuing due to Hurricane Katrina's disruption.

Experiment-1: Effects of elevated nutrient availability and flooding

Phase-I of experiment-1 was initiated in June of 2004 and was ended prematurely in August of 2005 as a result of flooding associated with Hurricane Katrina. The experimental design was a 3 x 3 x 2 completely cross-classified factorial with 3 levels each of both nitrogen and phosphorous and 2 levels of flooding, all replicated in 5 blocks for a total of 90 experimental units (n = 90). Nitrogen (2.5, 25, and 50 g N m^{-2} yr^{-1}) and phosphorous (0.5, 5, and 10 g P m^{-2} yr^{-1}) loading rates were based on mean annual outflow rates from the Caernarvon Diversion, Caernarvon, LA. Additions of N and P were administered weekly while micronutrient solutions were applied monthly, coinciding with the washing of the vessels. Vessels were washed and water was changed to minimize algal growth. Flooding depths were flooded to the surface of the mat and flooded to a depth of 15 cm (0 and 15 cm respectfully). Each experimental unit consisted of two square layers of DuraLast coconut fiber mat fastened together by plastic tie straps. This was essentially a hydroponic design that did not include a typical substrate material (i.e., the DuraLast coconut fiber served as the planting medium and substrate). Four individual plugs of commercially-grown *Panicum hemitomon* (maidencane) were planted into the corners of each double-layer mat sandwich, and each vegetated mat was placed in their respective experimental units. Each vessel was filled to near-capacity with DI water to ensure that manipulations of nutrient availability remained constant. Flooding treatments (0 and 15cm) were maintained by placing each vegetated mat on a segment of 4"PVC pipe that was cut to a pre-determined length.

Data collection included bi-weekly (initially) and then monthly measurements of cumulative stem height. Maximum root length and percent root coverage were measured and/or estimated bi-monthly, although these assessments did not occur until several months after the initiation of the experiment. Maximum root length represented the distance from the bottom of the vegetated mat to the tip of the longest root, while percent root coverage represented the percentage of area of the bottom of the vegetated mat with root tissue protruding from it. Net photosynthesis and stomatal conductance were measured at peak standing crop (after 12 months of growth) using a Li-Cor 6400 portable photosystem. Net photosynthesis and stomatal conductance were measured on a single leaf, second from the terminal leaf of each plant in each experimental unit. Each leaf was then clipped, dried and ground for CHN analysis. Root specific gravity was measured in June of 2005. Live root samples were clipped from each vegetated mat and taken to the Coastal Plant Sciences Laboratory for analysis. Root specific gravity was computed using the formula: $SG = R/ (P + R - PR)$, where R = mass of roots, P = mass of water-filled pycnometer, and PR = mass of pycnometer with roots and water. Biomass was measured on 62 of the 90 experimental units post-Katrina. The remaining 28 units were not identifiable, and consequently not recoverable. Biomass was divided into dead above- and belowground. Separating biomass into live and dead was not possible because the majority of the vegetated mats succumbed to desiccation stress. All biomass was oven-dried at 60˚C until a constant mass was attained.

Phase-II of experiment-1, initiated in March of 2006, was designed much like phase-I in terms of the experimental design and the expected outcomes. The experimental design was a 2 x 2 x 2 completely cross-classified factorial with 2 levels of both N and P loading, and two levels of flooding, replicated in 5 blocks for a total of 40 experimental units (n = 40). Nitrogen (25 and 50 g N m^{-2} yr^{-1}) and phosphorous (5 and 10 g P m^{-2} yr^{-1}) loading rates were based on mean annual outflow rates from the Caernarvon Diversion, Caernarvon, LA. As in phase-I, flooding depths were either flooded to the surface (0 cm)of the mat or flooded to a depth of 15 cm. The primary difference between phase-1 and phase-II was the addition of a true substrate to the double-layer DuraLast coconut fiber configuration. Sphagnum peat served as the substrate and was placed between the two layers of coconut fiber. Plastic tie straps were once again used to fasten the sandwich together. A single plug of maidencane was planted in the center of each DuraLast coconut fiber and peat sandwich. Plant material for phase-II was wild-harvested from the USDA Golden Meadow Plant Materials Center in Galliano, LA. Root stock was brought back to the UNO greenhouse facility and propagated until planting occurred.

Data collection followed a similar protocol as in phase-1, although several modifications and additions were made. Cumulative stem height was measured monthly over the 5 month course of the experiment. In an effort to minimize disturbance of each experimental unit, maximum root length and percent root coverage were not measured. On the other hand, substrate redox potential was measured in a bi-monthly fashion. As in phase-1, root specific gravity was assessed at peak standing crop (June 2006), as was net photosynthesis and stomatal conductance. Leaf samples were clipped, dried and ground for CHN analysis. The most significant changes in the methods for phase-II occurred at harvest. Each vegetated mat underwent a complete census which not only included the separation of biomass into above- and belowground components, but the separation of belowground biomass into roots and rhizomes Each vegetated mat was entirely dissembled and all biomass recovered. Aboveground biomass was clipped, although not separated into live and dead because all material was live at the time of harvest. The length of all rhizomes was measured, and all root tissue was set aide for further analyses. Complete root systems were scanned and quantified in terms of volume using an Epson 10000x scanner and Whin-Rhizo Pro-version root imaging software (Regent Instruments, Quebec, Canada). Furthermore, 5 individual root samples from each root system were reserved in order to assess individual root morphology, once again using Whin-Rhizo Pro-version root imaging software. All above- and belowground biomass was oven-dried at 60˚C until a constant mass was attained.

Experiment-2: Evaluation of substrate materials

Experiment-2 was initiated in October of 2004 and was ended prematurely in August of 2005 due to Hurricane Katrina. Prior to Katrina’s landfall this experiment was relocated from an exposed outdoor setting to a semi-protected greenhouse setting where it was spared damage (all plant material died due to desiccation stress however). The experimental design included one mat material (DuraLast coconut fiber), multiple substrate types (7 individual types and 5 blends), all replicated in 5 blocks for a total of 60 experimental units (n = 60). Individual substrate types included sphagnum peat, bagasse, sugarcane leaf strippings, pine shavings, cypress mulch, hardwood mulch, and pine bark mulch. Substrate blends included sphagnum peat x bagasse, sphagnum peat x hardwood mulch, sphagnum peat x cypress mulch, cypress mulch x bagasse, and hardwood mulch x sugarcane leaf strippings. The fertilization regime, applied once every three months, was uniform across all treatments (23.4 g N m^{-2} yr^{-1} and 2.0 g P m^{-2} yr^{-1}) and was once again based on mean annual outflow rates from the Caernarvon Diversion, Caernarvon, LA. Flooded conditions were maintained at 10 cm above the mat's surface in all treatments. A single plug of maidencane was planted in the center of each DuraLast coconut fiber and substrate sandwich. Plant material for experiment-2 was wild-harvested from the USDA Golden Meadow Plant Materials Center in Galliano, LA. Root stock was brought back to the UNO greenhouse facility and propagated until planting occurred.

Cumulative stem height was measured monthly over the duration of the experiment, while interstitial metrics such as pH, conductivity and substrate redox potential were measured bi-monthly. Net photosynthesis and stomatal conductance were measured on a single leaf, second from the terminal leaf of each plant in each experimental unit. These measurements were done using a Li-Cor 6400 portable photosystem. Each leaf was clipped, dried and ground for CHN analysis. Because all experimental units were not living at the time of salvage, harvest followed a different protocol than was originally intended. Above- and belowground biomass was separated but root and rhizome components were not distinguishable, nor were they separable from the substrate itself. Because of this, all belowground biomass had to be described in terms of a total change value. Pre-weights were determined at the outset of the experiment, and when combined with dry weights at the time of harvest, allowed for the calculation of a total change value. All biomass was oven-dried at 60˚C until a constant mass was attained.

A tag-on study to experiment-2 elucidating substrate chemical oxygen demand (COD) was conducted between February 2006 and September 2006. The 7 individual substrates, along with two controls (water only and water x DuraLast coconut fiber) served as the treatments. Each treatment was replicated 5 times for a total of 45 experimental units (n = 45). Interstitial samples were withdrawn at 6 times throughout the study (weeks 1-4, 6, 8, 20) and sent to Nichols State University in Thibadoux, LA for analysis. Interstitial pH was measured at each sampling, and substrate redox potential was measured 3 times over the 20-week period. Pre-weights were determined for all experimental units at the outset of the experiment, and final weights were determined at completion. This allowed for the calculation of substrate mass loss due to decomposition.

Experiment-3: Evaluation of containment materials

Experiment-3 was initiated in May of 2005 and, like experiment-2, was ended prematurely in August of 2005 due to Hurricane Katrina. Experiment-3 was also relocated from an exposed outdoor setting to a semi-protected greenhouse setting where it was spared damage (as with experiment-2, all plant material died due to desiccation stress). The overall objective of this experiment was not only to compliment the results of the substrate experiment (experiment-2), but to specifically assess maidencane growth responses when grown in conjunction with different commercially available mat or containment materials.

The experimental design included 5 mat materials and 1 substrate material (sphagnum peat), all replicated 5 times for a total of 25 experimental units (n = 25). Mat materials included two composed of coconut fiber (i.e., DuraLast coconut fiber and plain coconut fiber with plastic mesh) and one each of burlap, shredded birch and wheat straw. Each sphagnum peat and mat combination was housed in a 7.5-L container and flooded to a depth of approximately 10 cm above the surface of the mat. Fertilization, applied once every three months, corresponded to mean annual outflow rates of N and P (23.4 g N m^{-2} yr^{-1} and 2.0 g P m^{-2} yr^{-1}) from the Caernarvon Diversion, Caernarvon, LA. A single plug of maidencane was planted in the center of each mat and sphagnum peat sandwich. Plant material for experiment-3 was wild-harvested from the USDA Golden Meadow Plant Materials Center in Galliano, LA. Root stock was brought back to the UNO greenhouse facility and propagated until planting occurred.
Cumulative stem height was measured monthly over the course of the experiment, while interstitial pH and substrate redox potential were measured bi-monthly. Similar to that of experiment-2, harvest of this experiment did not proceed as planned due to Hurricane Katrina. All biomass was dead and therefore only separable into dead above- and belowground components. Above- and belowground biomass was separated but root and rhizome components were not distinguishable, nor were they separable from the substrate itself. All biomass was oven-dried at 60˚C until a constant mass was attained.

Experiment-4: Evaluation of edge-expansion

Experiment-4 was designed to determine maidencane growth response and overall mat development with inter-specific competition among common floating marsh plant species. Phase-I of this experiment was initiated in July of 2005 at an off-campus site owned and managed by the University of New Orleans. After a brief acclimation period, and before data collection could begin, this experiment was totally destroyed in August of 2005 by flooding and storm surge associated with Hurricane Katrina. Because of the severity of the impact and the early termination of the study, no further details are provided.

Phase-II was set-up and initiated in March of 2006 and was completed in September of 2006. It was conducted in an outdoor setting within the greenhouse complex at the University of New Orleans. The experimental design included 7 plant combinations and 5 plant establishment techniques, each replicated 4 times for a total of 48 experimental units (n=48). The 7 plant combinations included: *P. hemitomon* (maidencane) only, *P. hemitomon* x *Althernanthera philoxeroides* (alligator weed), *P. hemitomon* x *Hydrocotyle ranunculoides* (floating pennywort), *P. hemitomon* x *Ludwegia peploides* (floating swamp primrose), *P. hemitomon* x *Sagittaria lancifolia* (bull tongue), *P. hemitomon* x all edge species (excluding *S. lancifolia*), and *P. hemitomon* x all plant species (including *S. lancifolia*). Each treatment received 9 plugs of maidencane planted in a 3 x 3 grid fashion. Maidencane plant material for experiment-4 was wild-harvested from the USDA Golden Meadow Plant Materials Center in Galliano, LA. Root stock was brought back to the UNO greenhouse facility and propagated until planting occurred.

All other species were wild-harvested from various road-side wetlands in Orleans, Lafourche, Jefferson, or St. John the Baptist Parishes. Moreover, none of the non-maidencane species were propagated, they were gathered and planted within a 48 hour period. In all plant combinations DuraLast coconut fiber served as the mat material and sphagnum peat served as the substrate material. In regards to the 5 plant establishment techniques, *P. hemitomon* served as the only plant species considered. Establishment techniques included: *P. hemitomon* x chicken wire (in a hydroponic setting), *P. hemitomon* x chicken wire x humic acid amendment (also in a hydroponic setting), *P. hemitomon* x bagasse x DuraLast coconut fiber, *P. hemitomon* x DuraLast coconut fiber x peat x canvas underpinning, and *P. hemitomon* x DuraLast coconut fiber x peat x humic acid amendment. As in the planting treatments, 9 maidencane plugs were planted in a 3 x 3 grid fashion. All experimental units were housed in 1330-L livestock watering tanks filled to capacity with a combination of tap and rain water. Buoyancy was maintained in each treatment by a rigid PVC support structure. Additional support was provided by nylon rope fastened to the PVC structure. As in all previous experiments, the fertilization regime (23.4 g N m^{-2} yr^{-1} and 2.0 g P m^{-2} yr^{-1}) was based on mean annual outflow rates from the Caernarvon Diversion, Caernarvon, LA.

Data collection included monthly aerial photographs of each experimental unit in order to assess vegetative spread of each mat, as well as to estimate percent cover by species in the multi-species treatments. This was accomplished by constructing a large tripod that rested on the rim of each tank. An infra-red remote shutter release was used to ensure a clear photograph of each tank was attained. Each digital picture will be overlain by a grid of known size in order to determine plant species composition (note that these analyses have not occurred yet). At harvest each mat was removed from its tank and support structure and completely dissembled much like in phase-II of experiment-1. Maidencane aboveground biomass was clipped and set aside while maidencane belowground biomass was separated into roots and rhizomes. All belowground biomass was hand-picked from both the top and bottom layers of each mat. Moreover, in those treatments that contained substrate (i.e., non-chicken wire treatments), all substrate was washed and fine root tissue removed. The length of each rhizome segment was measured in order to determine a total rhizome length per mat. In this way total rhizome length provided a metric for inferring the lateral spreading potential of maidencane within each treatment. In multi-species treatments, all biomass was separated by species, including both above-and belowground components. However, above- and belowground biomass was not assessed independently for non-maidencane species, it was simply categorized as total biomass. Live root samples were taken from each species in order to determine root specific gravity. Root specific gravity was determined using the same formula used in experiment-1. All biomass, regardless of species, was oven-dried at 60˚C until a constant mass was attained.

Experiment-5: Assessment of P. hemitomon seed production and viability

Experiment-5 has not been undertaken at this point and its feasibility remains uncertain. *P. hemitomon* is considered to be an extremely poor seed producer even in favorable years, not to mention in years with above average tropical storm and/or hurricane activity.

Preliminary Results

Experiment-1: Effects of elevated nutrient availability and flooding

Preliminary findings indicate that although both above- and belowground production were enhanced with N and P loading, N limitation rather than P limitation appeared to be most important for plant growth (Figs. 8-10). This trend was not entirely unexpected, although it has been shown in the past that belowground production can be less under higher nutrient availability. Net negative changes in root mat weight (belowground plant material plus coconut-fiber mat; Fig. 9) that were observed under low and moderate nutrient loading rates are believed to be a result of mat decomposition, which apparently exceeded belowground production, during the 14-month course of the evaluation. Although *Panicum* produces very light-weight and buoyant (aerenchymous) belowground tissues, such change was not expected and will therefore be assessed in an additional experiment later this spring. There was no significant effect of flooding but overall the trend was for greater production under non-flooded conditions (i.e., flooded to the mat surface) (Figs. 9 and 10). It is thought that conditions in each of the flooded vessels were too thoroughly mixed for reduced conditions to develop. Consequently, significant differences aboveground growth and root specific gravity (i.e., aerenchyma formation) were not observed as has been reported when *Panicum* is flooded in a soil matrix that can become reduced (Fig. 11).

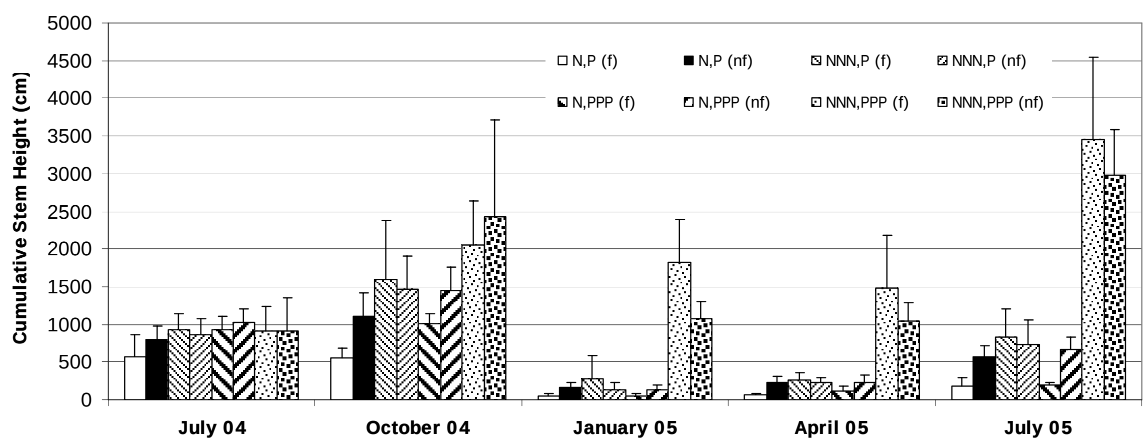


Figure 8. The effect of nutrient loading rate x flooding depth on cumulative stem height of *P. hemitomon*. Treatment codes are as follows: N,P (f) = low N and low P, flooded; N,P (nf) = low N and low P, not flooded; NNN,P (f) = high N and low P, flooded; NNN,P (nf) = high N and low P, not flooded; N,PPP (f) = low N and high P, flooded; N,PPP (nf) = low N and high P, not flooded; NNN,PPP (f) = high N and high P, flooded; NNN,PPP (nf) = high N and high P, not flooded. Flooded indicates flooded to a depth of 15 cm. Non-flooded indicates flooded to the mat surface. For each pair of bars, the left represents the flooded treatment and the right represents the non-flooded treatment. Values are means ± standard error.

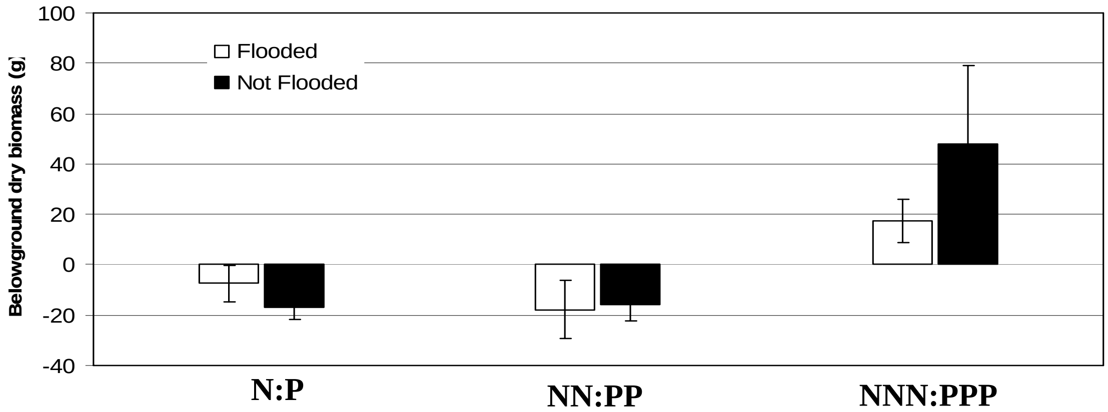


Figure 9. The effect of nutrient loading rate x flooding depth on belowground production by *P. hemitomon*. Treatments are as follows: N,P = low N and low P; NN,PP = medium N and medium P; NNN,PPP = high N and high P. Note that all treatment combinations are not shown. Values are means ± standard error.

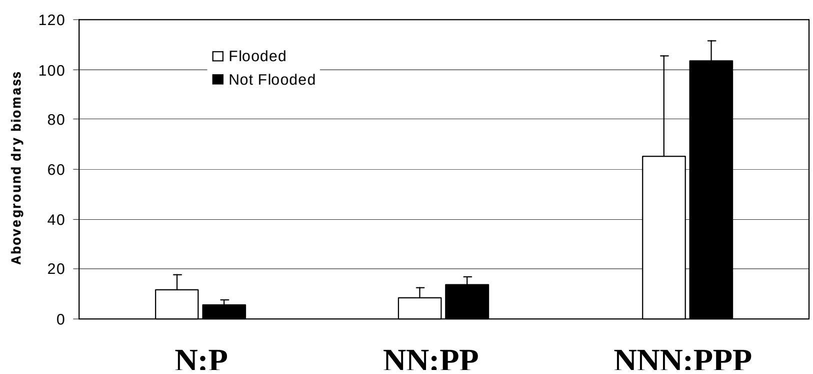


Figure 10. The effect of nutrient loading rate x flooding depth on aboveground production by *P. hemitomon*. Treatments are as follows: N,P = low N and low P; NN,PP = medium N and Medium P; NNN,PPP = high N and high P. Note that all treatment combinations are not shown. Values are means ± standard error.

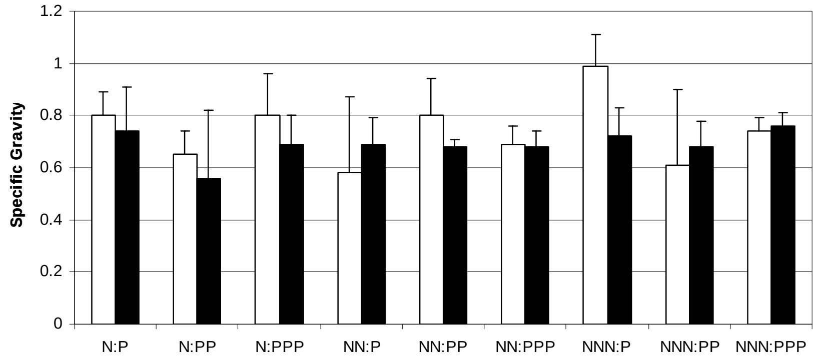


Figure 11. The effect of nutrient loading rate x flooding depth on root specific gravity of *P. hemitomon*. Un-shaded bars (left in each pair) represent those treatments flooded to a depth of 15 cm. Shaded bars (right in each pair) represent non-flooded treatments. Values are means ± standard error.

Experiment-2: Evaluation of substrate materials

Preliminary findings from this evaluation indicate that significant differences do exist in above- and belowground production as influenced by substrate type. For example, cumulative stem height varied significantly by both time and substrate type (Fig. 12). Overall *P. hemitomon* performed better in the presence of a peat-based substrate (i.e., pure peat and particular peat blends) (Figs. 12-15). However, in terms of net total biomass accumulation, peat and peat x cypress substrates provided the most favorable conditions for growth (Figs. 13-16).

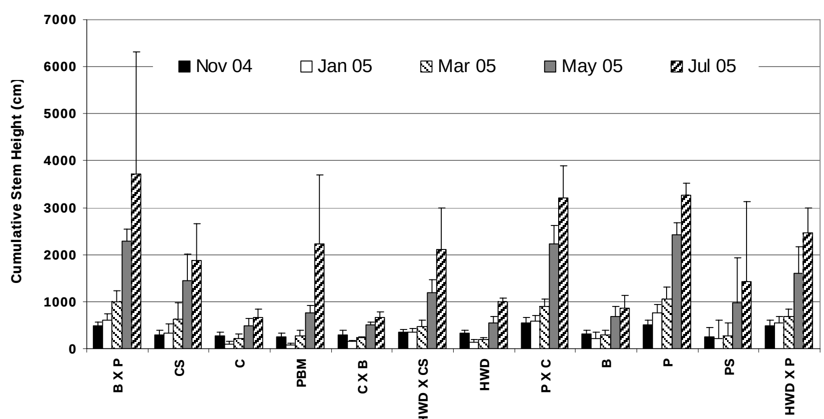


Figure 12. The effect of substrate type on cumulative stem height of *P. hemitomon.*Codes for substrate types are as follows: B x P = bagasse x peat: CS = sugarcane leaf-strippings; C = cypress mulch; PBM = pine bark mulch; C x B = cypress mulch x bagasse; HWD x CS = hardwood mulch x sugarcane leaf-strippings; HWD = hardwood mulch; P x C = peat x cypress mulch; B = bagasse; P = peat; PS = pine shavings; HWD x P = hardwood mulch x peat. Values are means ± standard error.

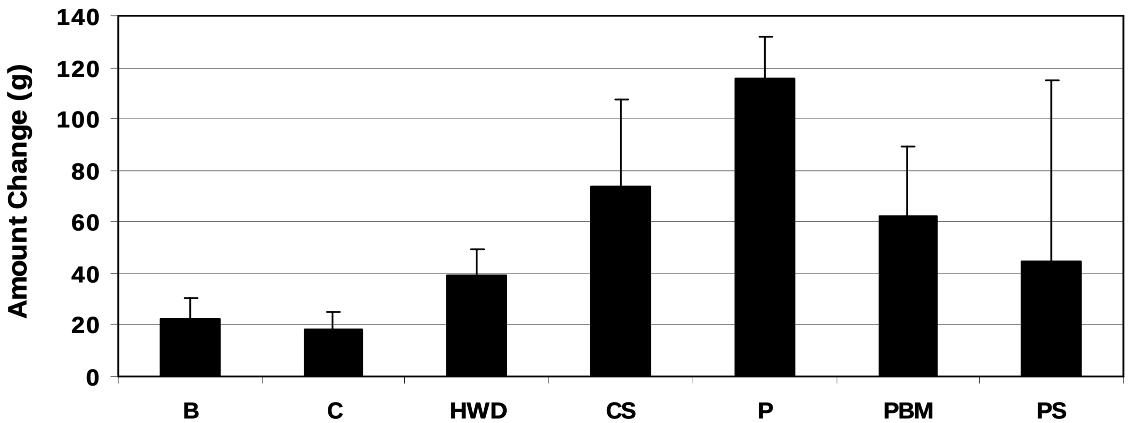


Figure 13. The effect of substrate type (non-blends) on aboveground production by *P. hemitomon*. Treatment codes are as follows: B = bagasse; C = cypress mulch; HWD = hardwood mulch; CS = cane (sugarcane) leaf strippings; P = peat; PBM = pine bark mulch; PS = pine shavings. Values are means ± standard error.

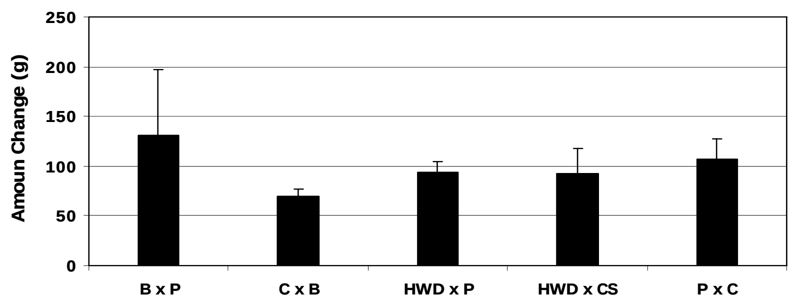


Figure 14. The effect of substrate type (blends) on aboveground production by *P. hemitomon*. Treatment codes are as follows: B x P = bagasse x peat; C x B = cypress mulch x bagasse; HWD x P = hardwood mulch x peat; HWD x CS = hardwood mulch x sugarcane leaf strippings; P x C = peat x cypress mulch. Values are means ± standard error.

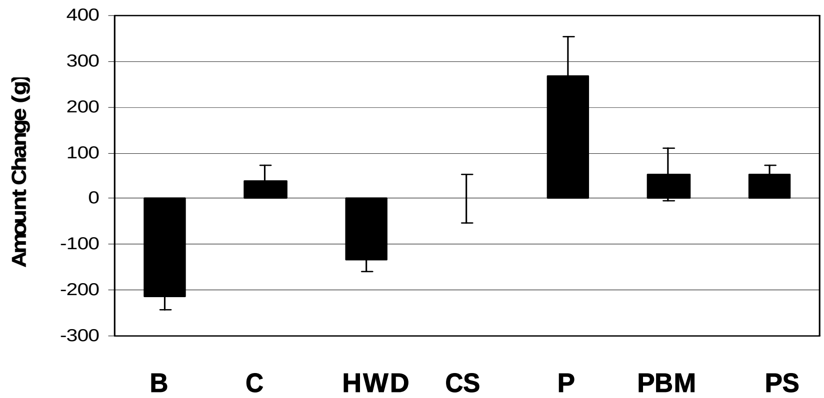


Figure 15. The effect of substrate type (non-blends) on belowground production by *P. hemitomon*. Treatment codes are as follows: B = bagasse; C = cypress mulch; HWD = hardwood mulch; CS = sugarcane leaf strippings; P = peat; PBM = pine bark mulch; PS = pine shavings. Values are mean ± standard error.

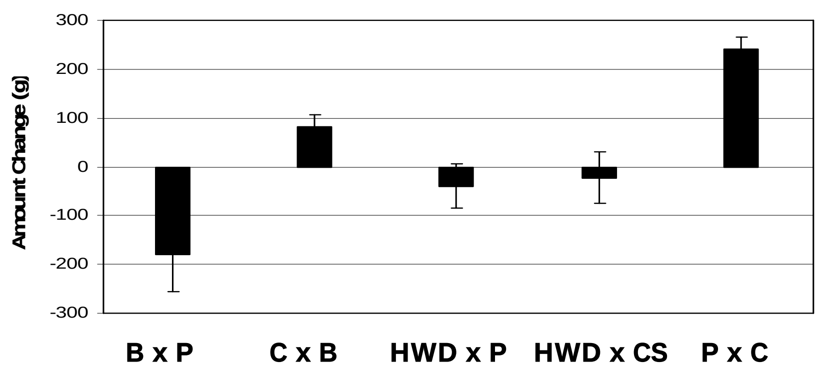


Figure 16. The effect of substrate type (blends) on belowground production by *P. hemitomon*. Treatment codes are as follows: B x P = bagasse x peat; C x B = cypress mulch x bagasse; HWD x P = hardwood mulch x peat; HWD x CS = hardwood mulch x cane leaf strippings; P x C = peat x cypress mulch. Values are means ± standard error.

Several substrates (e.g., bagasse, hardwood mulch and hardwood mulch x cane leaf strippings) appeared to have decomposed, resulting in net belowground weight loss (Fig. 16). Determining the degree to which different substrates affected specific root attributes (root morphology and root specific gravity) was not possible due to hurricane impacts. This will be assessed later this spring and summer.

Experiment-3: Evaluation of containment materials

Preliminary results from the mat evaluation, after only 3 months of growth, suggest that growth and performance by *P. hemitomon* varied little in relation to mat type. The exceptions are those plants grown in conjunction with birch matting. Both above- and belowground production were significantly less when birch was used (Figs. 17-18).

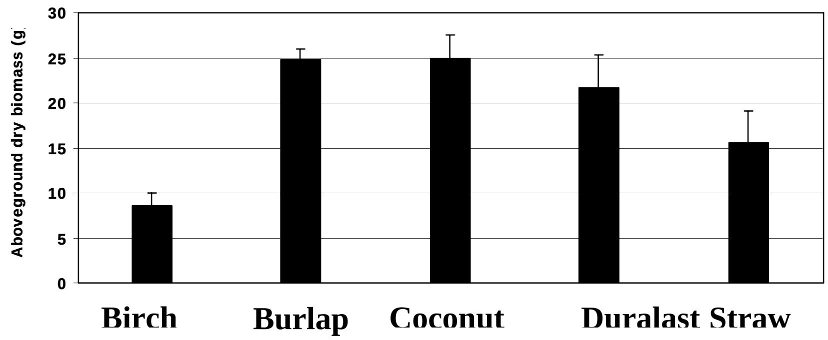


Figure 17. The effect of mat type on the aboveground production by *P. hemitomon*. Values are means ± standard error.

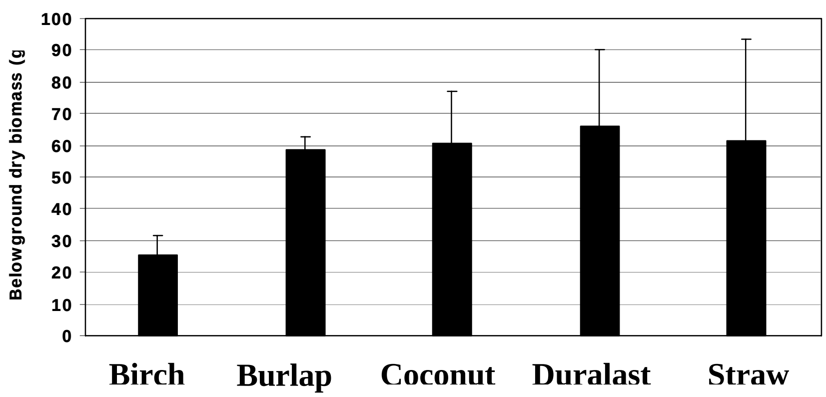


Figure 18. The effect of mat type on belowground production by *P. hemitomon*. Values are means ± standard error.

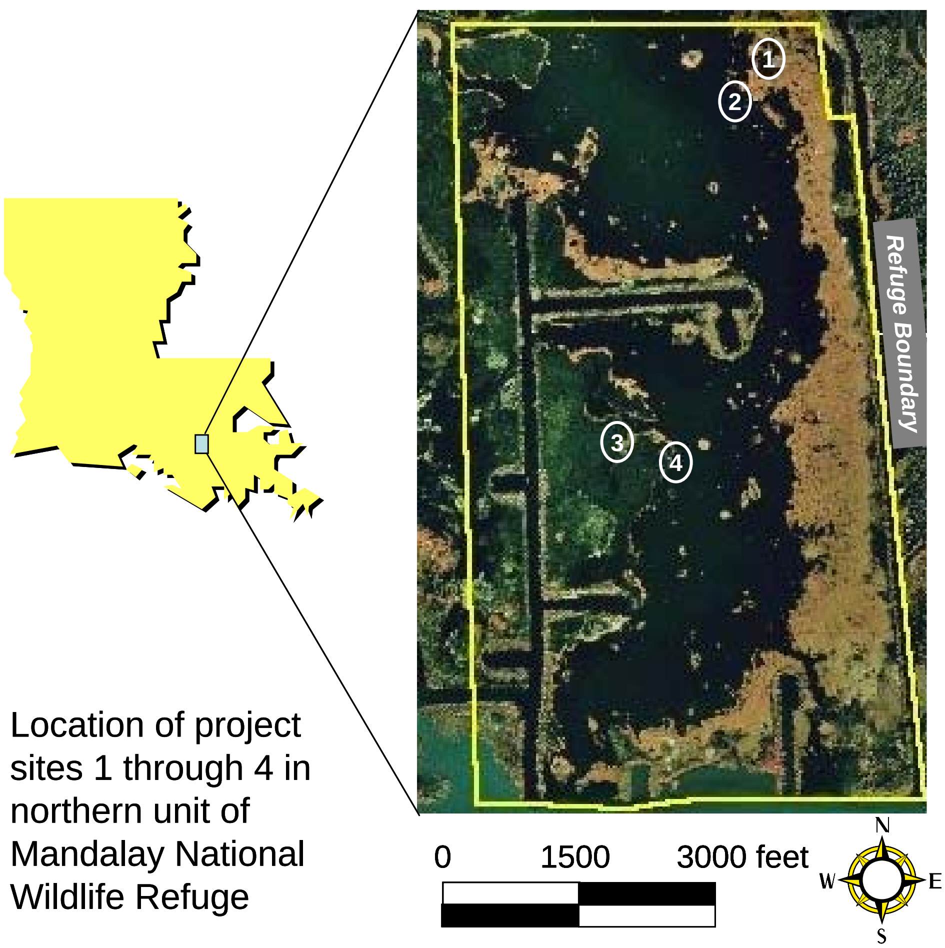
Task 7 – Year 1 Monitoring and Report

The Year 1 Annual Report including testing methodologies and results of the activities undertaken in the first year of the floating marsh creation demonstration project was prepared and delivered to DNR in June 2005.

Task 8 – Year 2 Mat Development and Deployment

After receiving concurrence from DNR in March 2006 on the recommended AFS designs for deployment at the Mandalay National Wildlife Refuge (see Task 6), we constructed (Task 8.1) and deployed (Task 8.2) 300 AFS structures containing maidencane vegetation. The field deployment was implemented at the four previously identified marsh sites in the Mandalay National Wildlife Refuge. The construction and deployment of the vegetated structures at the field sites was completed by 1 June 2006. A summary of the deployment is provided below.

Field Deployment

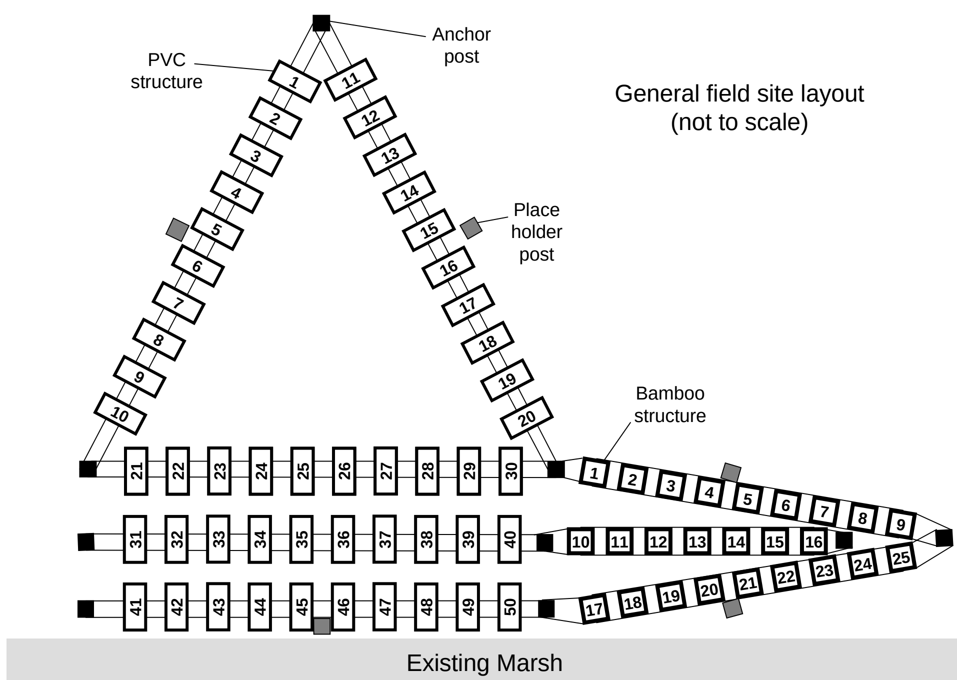


Location of project sites 1 through 4 in northern unit of Mandalay National Wildlife Refuge

Mandalay National Wildlife Refuge (MNWR) in Terrebonne Parish Louisiana was selected as the location for field deployment. The MNWR is located within the historical area that once supported a large expanse of thick-mat floating maidencane marsh that in recent decades has undergone extensive conversion to open water and/or thin-mat floating marsh. The U.S. Fish and Wildlife Service has issued a Special Use Permit for full implementation of the project. Within MNWR 4 deployment sites were identified. Two deployment sites are in large open water bodies, and two deployment sites are in small open water bodies. The small open water bodies are small enough that the deployed structures occupy greater than 50% of the available space. Sites 2 and 4 are located in a large pond and are open to wind vetch. Sites 1 and 3 are in small ponds and are protected from wind vetch in most directions.

Based on the structural integrity, buoyancy, and growth response results from the Phase 1 investigations, two successful AFS designs were brought forward for field deployment in a marsh setting (see results section). The first design uses PVC for buoyancy and is based on AFS 26. The AFS 26 design was modified by adding two additional spacers in between the PVC tubes. This improved PVC design was repeated 50 times at each deployment site for a total of 200 structures. The second design uses bamboo for buoyancy and is the AFS 22 design. This bamboo design was repeated 25 times at each deployment site for a total of 100 structures.

Structure construction started in February, 2006. The PVC designs were deployed first. The sites were completed in order of their site number. Site 1 received the first structures in April, 2006. Site 4 received the final PVC structure on May 11, 2006. Bamboo structures were constructed and deployed from May 16 through June 1, 2006.



Two methods for establishment were used with each structure design:

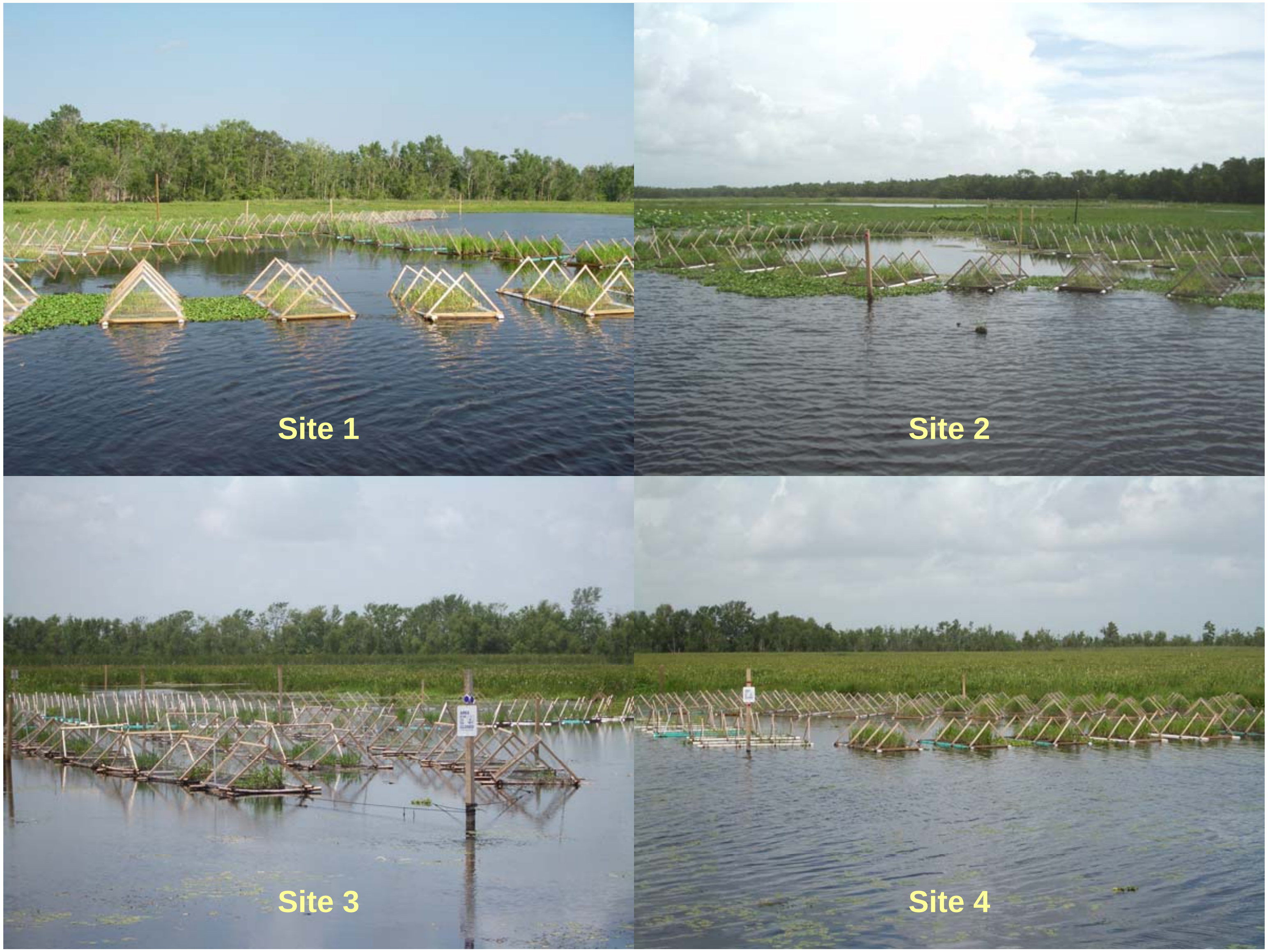
1. *Panicum hemitomon* in peat pots.
2. *Panicum hemitomon* stems

For the PVC design we used 30 pots per structure, and for the bamboo design we used 10 pots per structure. These numbers of pots provide an average density of 1 pot per square feet of structure. For the stem planted structures we used stems from the number of pots that would be used if the structure was planted with pots (approximately 30 stems in the bamboo structures and 90 stems in the PVC structures). In half of the PVC structures *P. hemitomon* was established in pots and in the other half it was established from stems. All PVC structures were fenced, except for five replicates of each establishment technique at each site. Nine of the bamboo structures at each site utilized stem establishment and 16 used pot establishment. None of the bamboo structures were left unfenced.

Monitoring

Monitoring of the vegetated structures deployed at Mandalay will include data collected from 5 replicates of each treatment combination at each site. Treatment combinations are:

Structure type	**Establishment technique**	**Grazing treatment**
PVC	Pots	Fenced
PVC	Pots	Grazed
PVC	Stems	Fenced
PVC	Stems	Grazed
Bamboo	Pots	Fenced
Bamboo	Stems	Fenced



Site condition on May 31, 2006

SUMMARY OF TASKS COMPLETED AND REMAINING

Tasks Completed:

Task 1 – AgCenter Program Development
Year 1 Deliverable: Monthly, quarterly, and annual reports
Year 2 Deliverable: Annual report

Task 2 – Comprehensive Project Plan Development
Deliverable: Final Comprehensive Project Plan

Task 3 – Comprehensive Monitoring Plan Development
Deliverable: Final Comprehensive Monitoring Plan

Task 4 – Landrights Acquisition
Deliverable: Special Use Permit from the Mandalay National Wildlife Refuge

Task 5 – Environmental Compliance
Deliverable: Final Project Plan and Environmental Assessment, and General permit from USACE for the project work

Task 6 – Year 1 Mat Development and Selection
Deliverable: Completed production and testing of AFS designs under controlled outdoor settings. UNO work disturbed by Hurricane Katrina is ongoing.

Task 7 – Year 1 Monitoring and Report
Deliverable: Year 1 Annual Report

Task 8 – Year 2 Mat Development and Deployment
Task 8.1 Deliverable: Production of AFS structures completed June 2006
Task 8.2 Deliverable: Field deployment of AFS treatments completed June 2006

Tasks Outstanding or In Progress:

Task 9 – Year 2 Monitoring and Report
Deliverable due by January 31, 2007

Task 10 – Year 3 Maintenance and Rehabilitation
Deliverable due May 31, 2007

Task 11 – Year 3 Monitoring and Report
Deliverable due May 31, 2007

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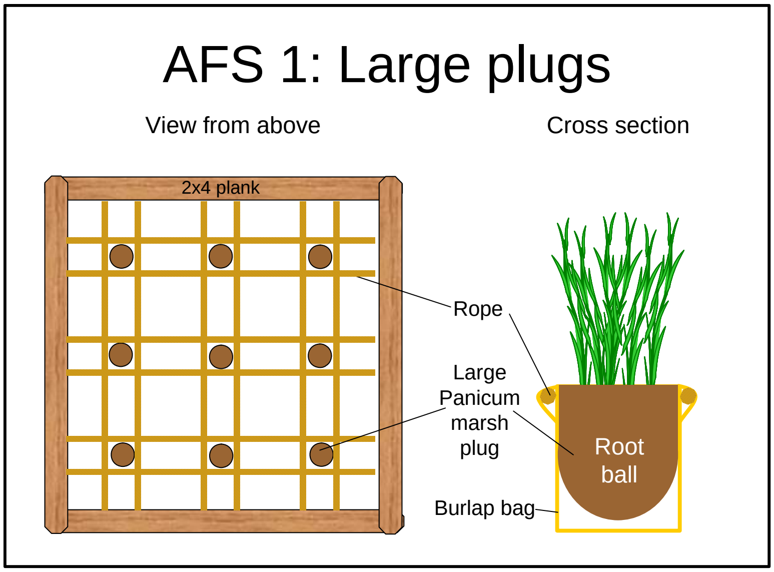
Appendix A

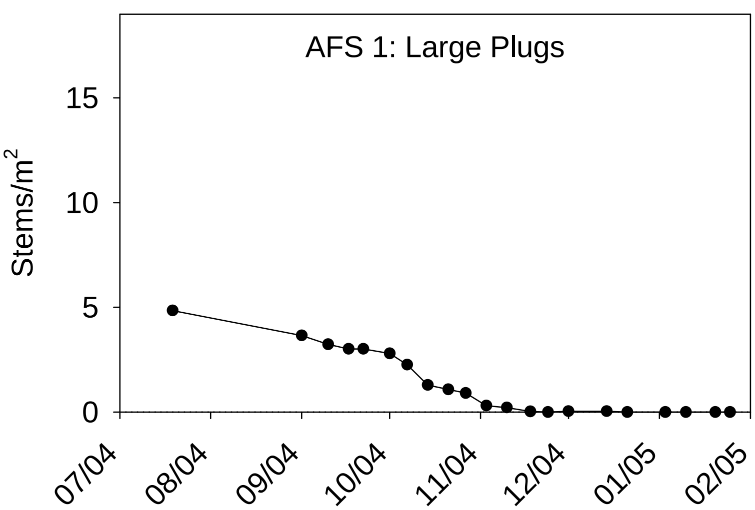
Overview of Artificial Floating Systems
Tested at LSU AgCenter Ben Hur Aquaculture Ponds
July 2004 - October 2005

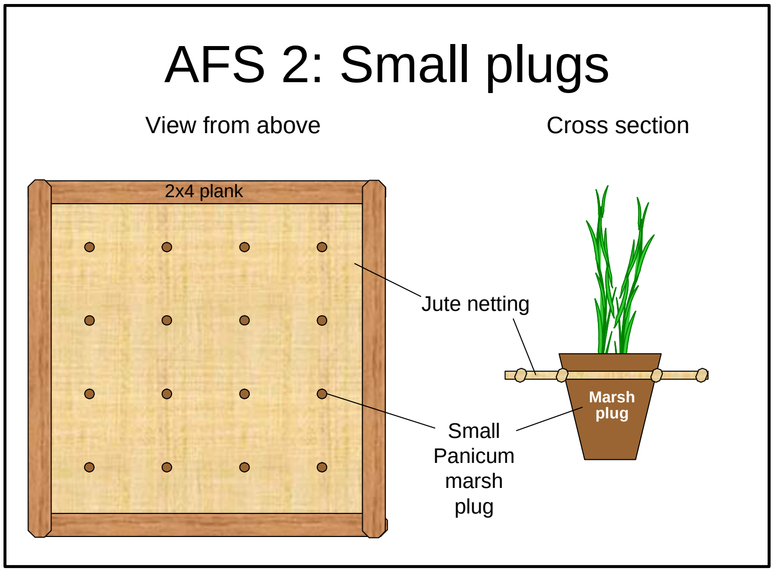


Artificial Floating Structure 1

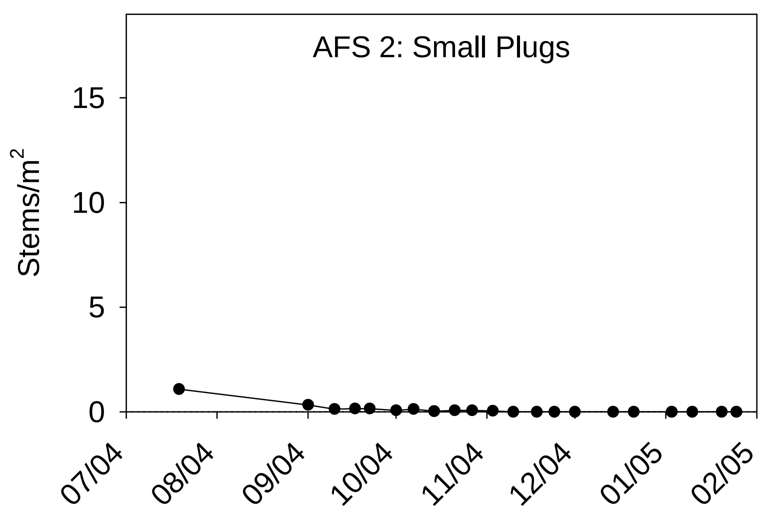
The design for this AFS provides a structure that evenly spaces “large” (~ 5 gallon bucket) plugs of *P. hemitomon.* This AFS is approximately 3 m (10 ft) on each side and contains 9 large plugs. The frame was constructed with buoyant wooden planks and plugs were evenly distributed within the frame using cotton ropes. The plugs will be kept in place using burlap sacks that are attached to the ropes.

This picture shows AFS 1 near the peak of its performance on September 22, 2004. Soon after, all plugs were heavily grazed. No living vegetation was observed in these structures from early November 2004. Four of the structures have remained floating. One structure partially submerged during the winter months. By the end of February, the burlap bags and some of the ropes were starting to deteriorate. It is not possible to fence these structures to exclude nutria and muskrat, due to the large holes on the bottom that provide easy access for aquatic herbivores. These structures were removed from the ponds in March 2005.






AFS 2 on September 22, 2004

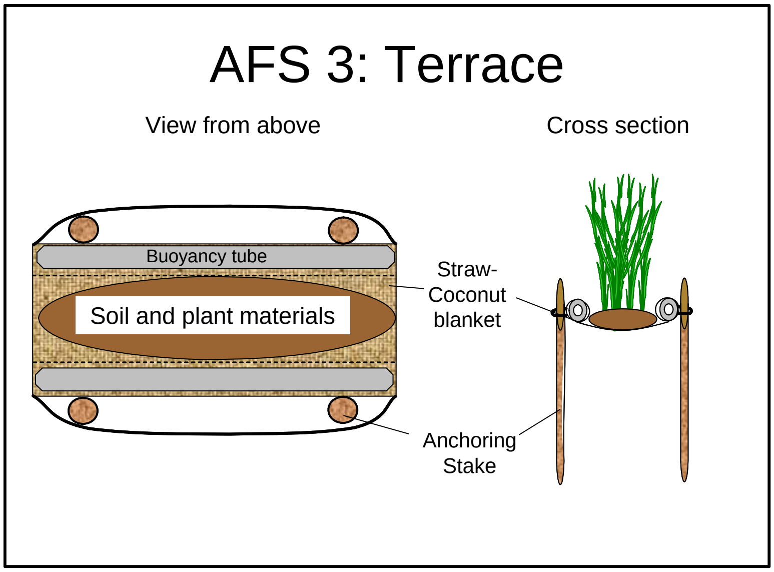


Artificial Floating Structure 2

The design for this AFS provides a structure that supports small plugs of *P. hemitomon* marsh. This AFS is approximately 3 m (10 feet) on each side and contains 16 small plugs. The frame was constructed with buoyant wooden planks and plugs were evenly distributed within the frame using a loosely woven jute material.

At the time of deployment it became apparent that additional bracing was necessary because of excessive sagging of the jute netting. This cross bracing can be seen in the picture. Vegetation never really established in these structures and the jute netting started to deteriorate approximately 2 months after deployment and no material was left by the end of February. Four of the structures remained floating and one has been submerged floating since early September. Because of the poor performance these structures were removed from the ponds in March 2005.

Artificial Floating Structure 3

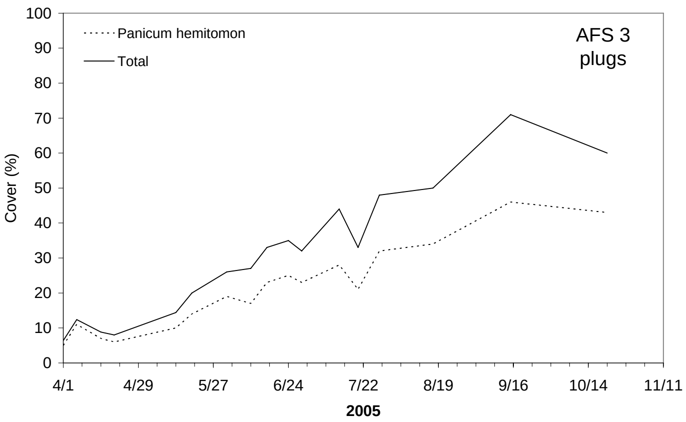


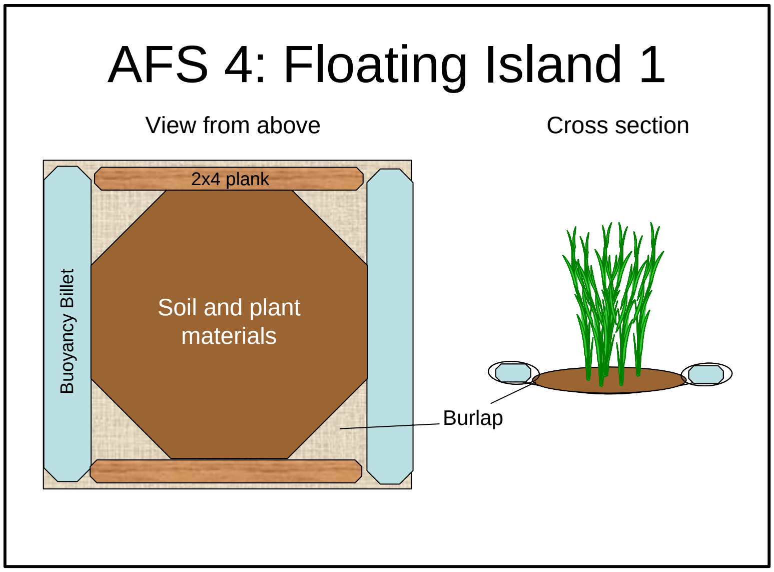
The design for this AFS consists of a hammock like containment system, filled with substrate and planted with nursery grown *P. hemitomon*. This AFS is approximately 3 m (10 ft) long and 1 m (3 ft) wide. The hammock was constructed using North American Green SC250, a 70% straw-30% coconut fiber matrix incorporated into a permanent three-dimensional turf reinforcement matting. Each side of the straw-coconut fiber hammock was made buoyant using a buoyancy tube (PVC pipe filled with marine foam). The hammock was filled with a 5 cm (2 in) layer of organic soil material and planted with 10 *P. hemitomon* plants (small nursery stock).


AFS 3 on March 23, 2005


AFS 3 on August 22, 2005

All of these structures have been floating at the surface. The coconut-straw mat has remained in place although some of the organic mat material is disappearing. These structures were relatively well vegetated during the early fall of 2004. Although these structures were grazed, grazing pressure seemed lower than on some of the other structures. However, to improve vegetation establishment, these structures were replanted with 10 marsh plugs and fences were added to the structures in March 2005. The added plugs remained in good condition through the end of the growing season and *P. hemitomon* cover has increased from 5% on April 1 to a maximum of 46% on September 15, 2005.

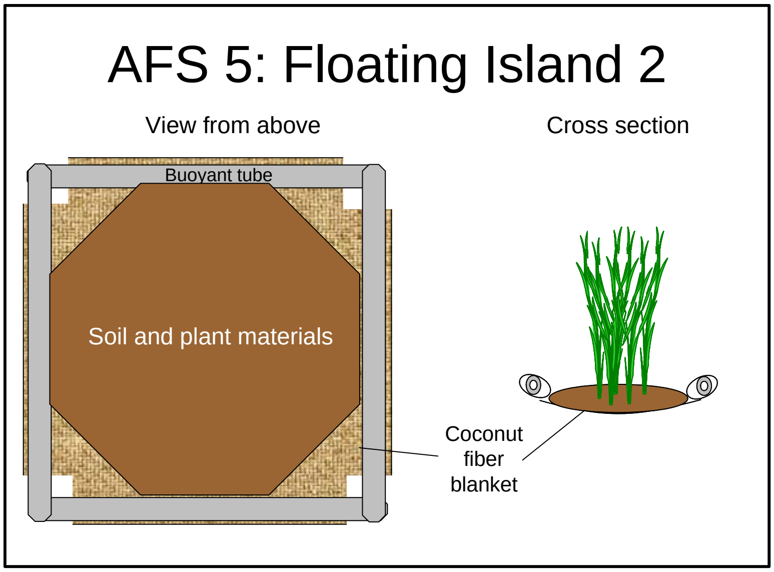


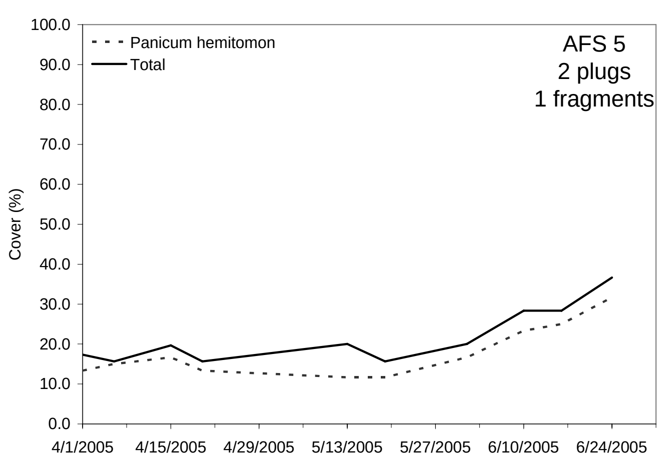


Artificial Floating Structure 4

This design used commercially available buoyancy billets (for floating dock construction) for flotation that are kept separated with wooden planks with a burlap hammock topped with 5 cm (2 in) of organic soil and planted with 20 *P. hemitomon* plants.

Structures attracted grazers and burlap deteriorated as a result. Plants never really got established in these structures as demonstrated by the top picture from September 22, 2004. Because these designs lost their structural integrity as demonstrated in the bottom picture from October 31, 2004, they were removed from the ponds in October 2004.

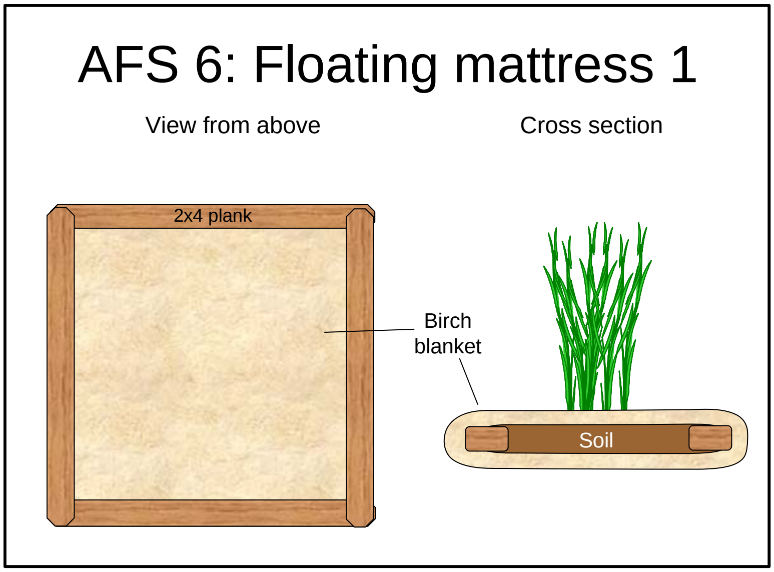




Artificial Floating Structure 5

This design consists of four approximately 3 m (10 ft) PVC tubes filled with closed cell Styrofoam that support a coconut fiber fabric topped with 5 cm (2 in) of organic soil and was planted with 20 *P. hemitomon* plants (small nursery stock). The coconut fiber mat used for this design consists of two layers of the North American Green C125, a 100% coconut fiber with a functional longevity of approximately 36 months.

These structures were floating at the surface through early December, when one of them partially submerged. Vegetation did relatively well in these structures during the early fall. Fences were added to these structures in October 2004. However, by the end of February very limited resprouting of the vegetation had been observed. Because the coconut mat was still in good condition, two of these structures were replanted with plugs, and one with shredded plugs in March 2005. The fourth structure, which partially submerged was removed. All the transplanted material has remained in good condition but *P. hemitomon* cover remained more or less stable at 13% through May, but increased to 32% by June 24, 2005. Monitoring of these structures stopped in July.



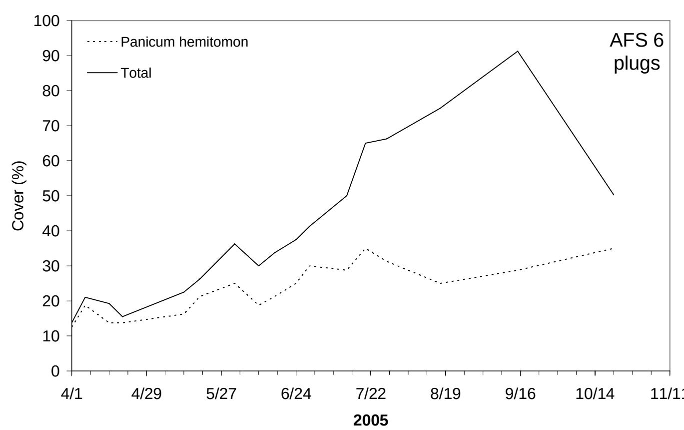
Artificial Floating Structure 6

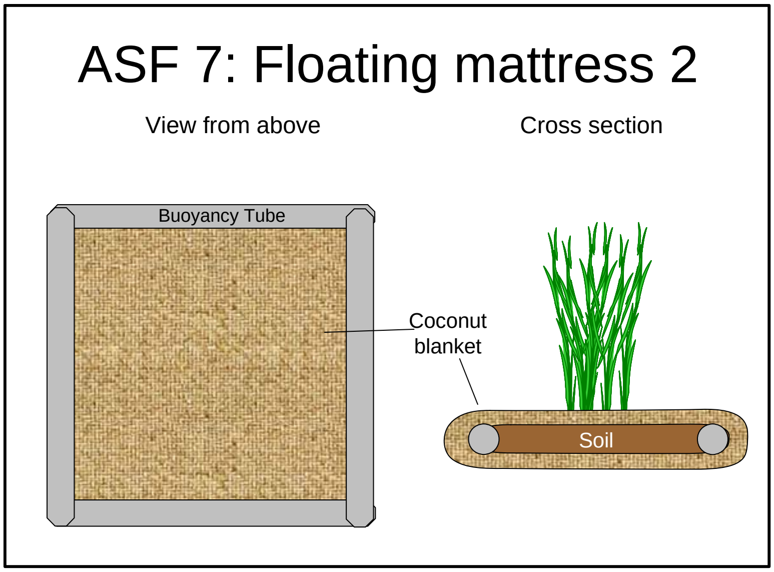
This design created a piece of floating marsh by sandwiching about 5cm (2 in) of organic soil material between two birch fiber blankets (Western Excelsior SD-3). Rigidity and buoyancy were achieved with a wooden frame that was 1m by 1 m (4 x 4 ft). The mattress was planted with 10 *P. hemitomon* plants (small nursery stock).

All structures have been floating at the surface. Structures were fenced and replanted in October 2004. The birch mat has remained in excellent condition. Vegetation died-back during the winter months, but started increasing in February 2005. However, in order to improve vegetation establishment, these structures were replanted with 5 marsh plugs in March 2005. Average *P. hemitomon* cover was 12% on April 1, 2005, and reached a peak of 35% by July 20, 2005. Other species, especially, *Ludwigia* sp. out-competed *P. hemitomon* in the late growing season.


AFS 6 on April 1, 2005


AFS 6 on August 22, 2005

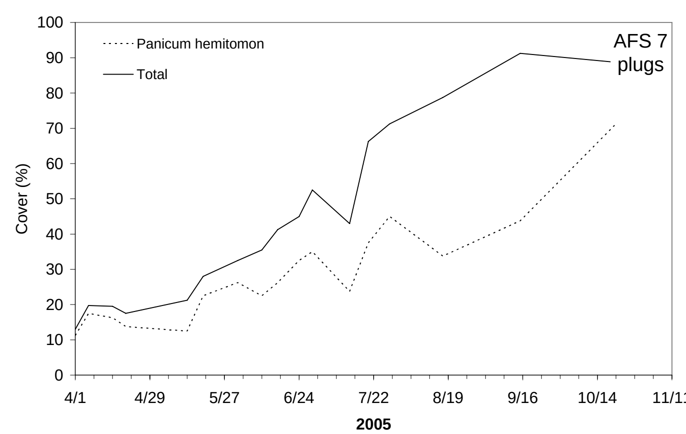




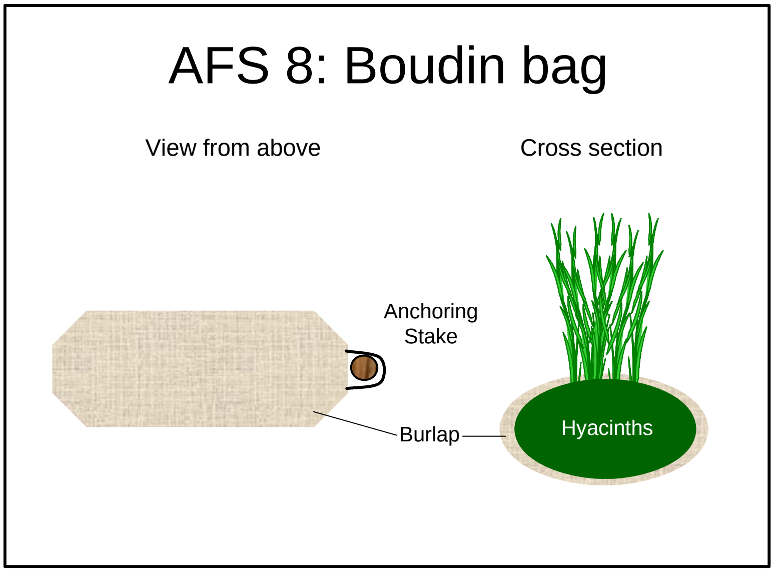
Artificial Floating Structure 7

This design created a piece of floating marsh by sandwiching about 5cm (2 in) of organic soil material between two coconut fiber blanket (Western Excelsior CC-4). Rigidity and buoyancy were achieved with a PVC frame that was 1m by 1 m (4 x 4 ft). The mattress was planted with 10 *P. hemitomon* plants (small nursery stock).

All structures have been floating at the surface, except for one structure that sunk in September 2004 and was removed from the pond. Structures were fenced and replanted in October 2004. The coconut mat has remained in excellent condition. Vegetation died-back during the winter month, but started increasing in February 2005. However, in order to improve vegetation establishment, these structures were replanted with 5 marsh plugs in March 2005. The added plugs remained in good condition through the end of the growing season and *P. hemitomon* cover has increased from 11% on April 1 to 71%. Although other species occurred in these structures, they never out competed *P. hemitomon*.

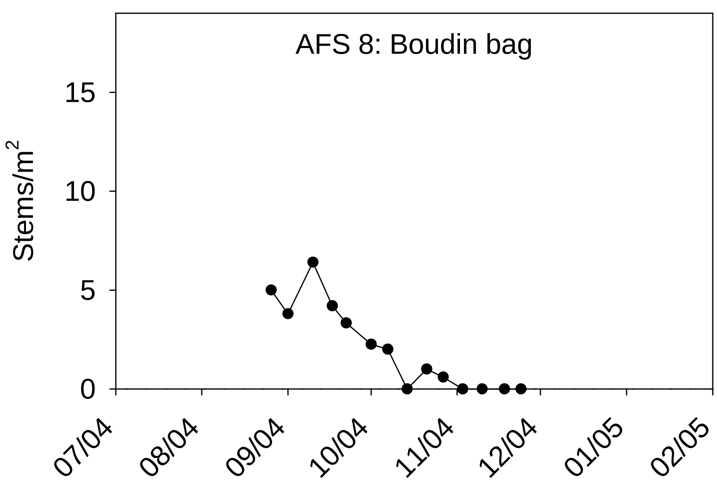


Artificial Floating Structure 8

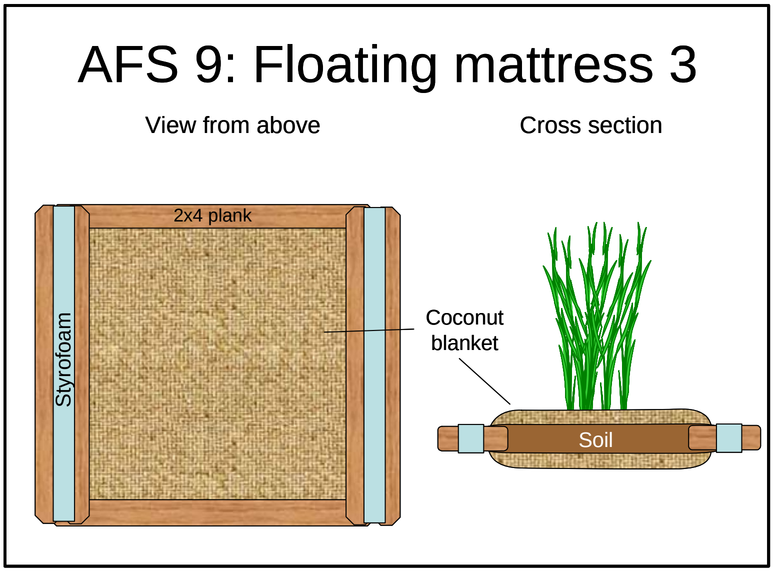


A bag was constructed from burlap material and filled with water-hyacinths. The bag was 1 m by 1m (4 x 4 ft) and was planted with 10 *P. hemitomon* plants (small nursery stock).

The plants on these structures were grazed and the structures showed erratic floating behavior during the fall of 2004. All structures sank with colder temperatures at the end of November 2004. None have re-emerged by March 2005.

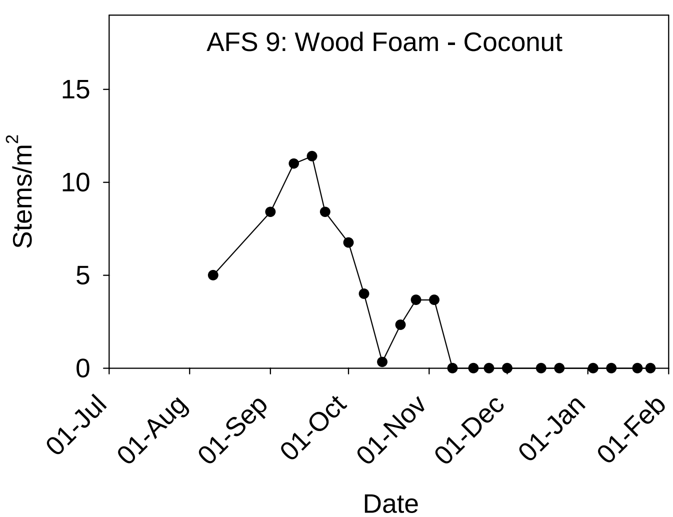


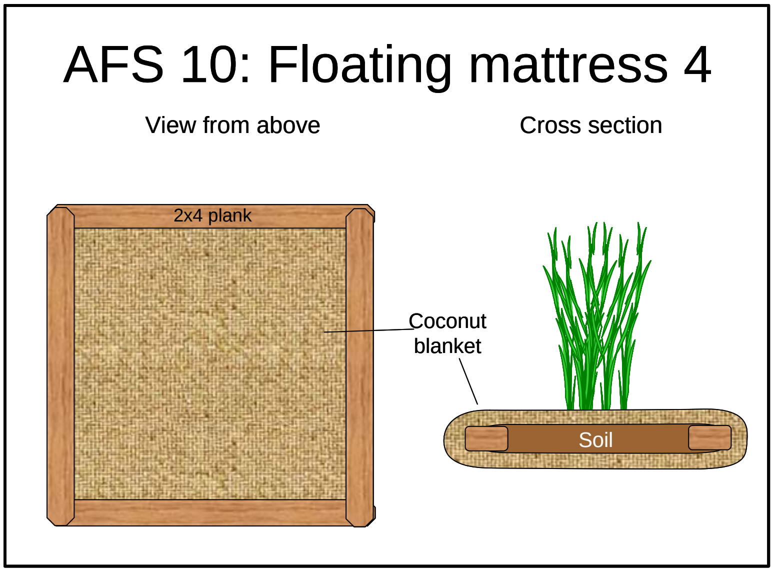
Additional Designs Started in the Fall of 2004



Artificial Floating Structure 9

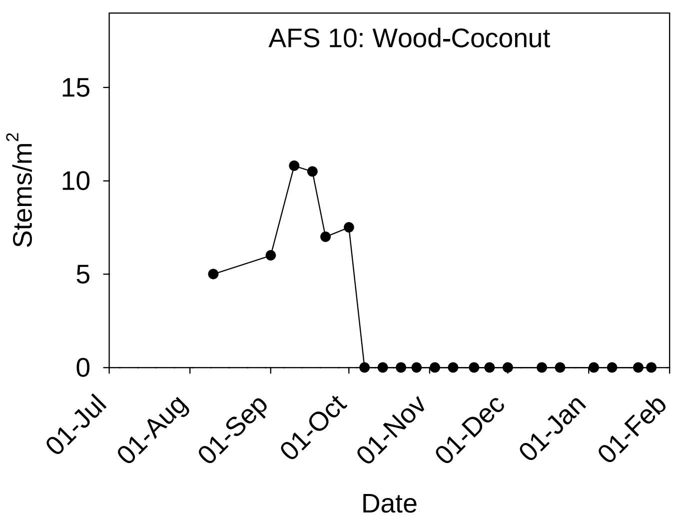
This design is similar to AFS 6 the only difference is that instead of the birch fiber blanket a coconut blanket was used. To increase the buoyancy, two pieces of Styrofoam were attached with Nylon cable ties. These structures were buoyant through most of the test period. However, grazers like to rest on the foam. Three structures were removed, because animals broke the cable ties that fasten the floats to the structure.





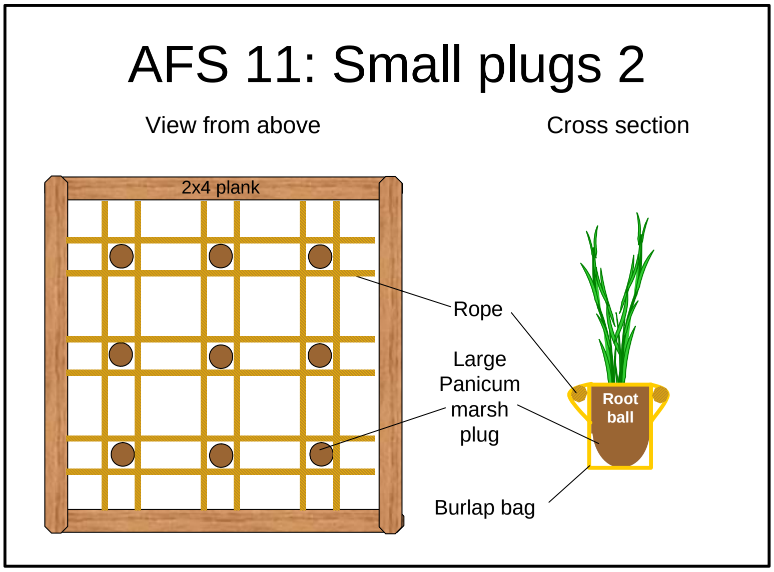
Artificial Floating Structure 10

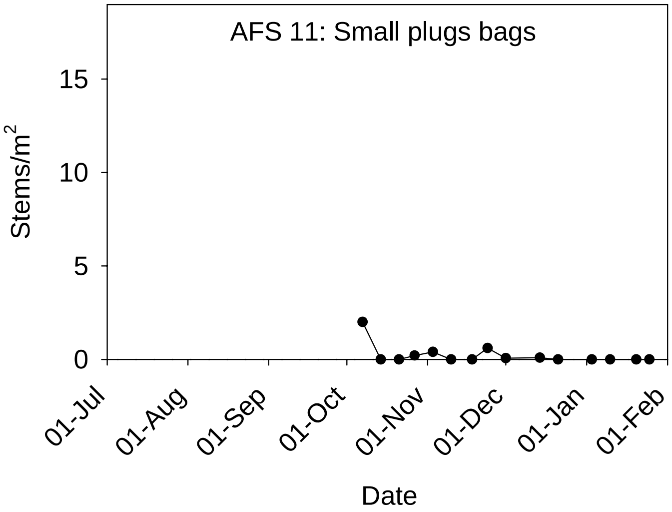
This design is similar to AFS 6 the only difference is that instead of the birch fiber blanket a coconut blanket was used. Four of the five structures sank, therefore all structures were removed from the ponds. A comparison of AFS 10 with AFS 7 and AFS 9 illustrates that the coconut fiber blanket requires a support structure with higher buoyancy than that provided by wood.



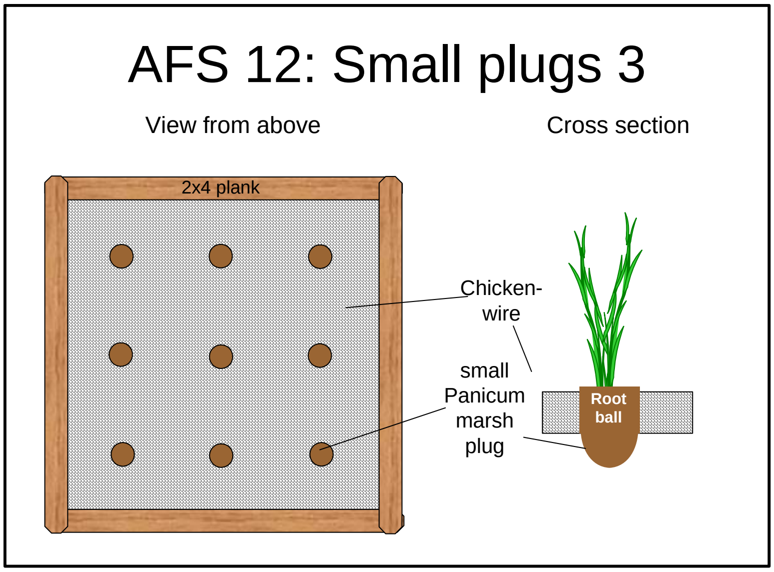
Artificial Floating Structure 11

This design is a miniaturization of AFS 1. All plugs in this design were heavily grazed and no vegetation survived. Four of the structures have been floating at the surface and one sank. Because of deterioration of the burlap material and not being able to protect the structure from aquatic herbivores, these structures were removed in March 2005.

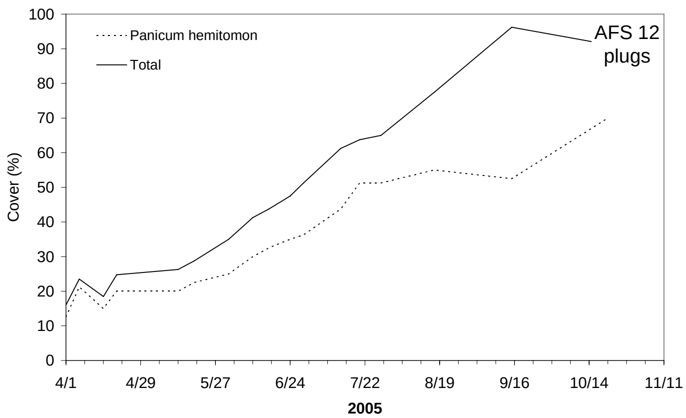




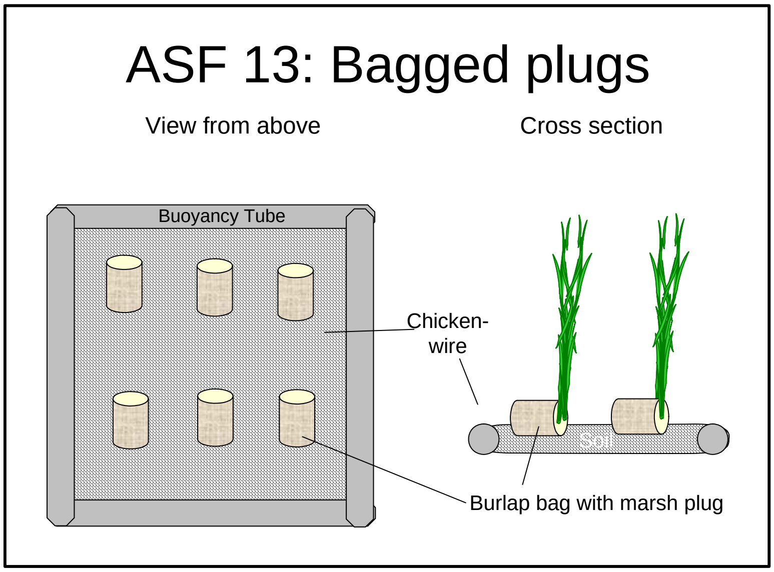
Artificial Floating Structure 12



This design uses a wood frame with a chicken-wire mattress. Nine small plugs marsh vegetation were placed inside these structures. These plugs were heavily grazed immediately following deployment. Structures were fenced in October 2004. However, little recovery of vegetation was observed during the winter. Four of the structures have been floating at the surface and one sank. The four floating structures were replanted with 9 plugs in March 2005. The added plugs remained in good condition through the growing season and *P. hemitomon* cover has increased from 12% on April 1 to 70%. Although other species occurred in these structures, they never out competed *P. hemitomon*.

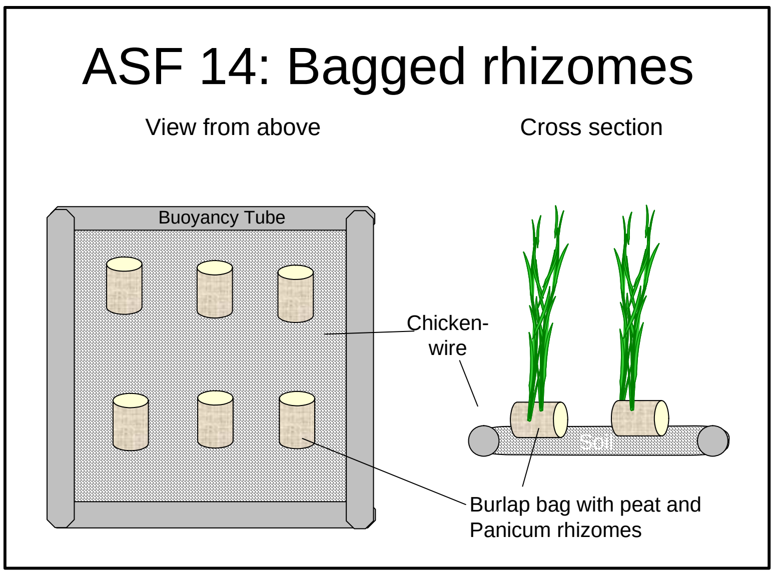


Additional Designs Started in the Spring of 2005



Artificial Floating Structure 13

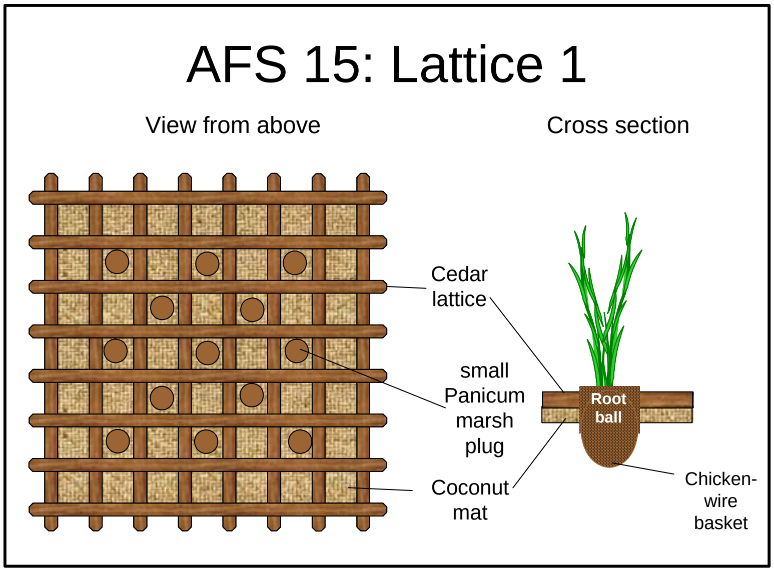
This design uses a PVC frame with a chicken-wire hammock. The frame supports 6 marsh plugs with the root mat enclosed in a small burlap bag. This design is currently unfenced. Average *P. hemitomon* cover was 7.5% on April 1, 2005, and hovered around that value throughout the growing season. Periodically signs of grazing were observed.



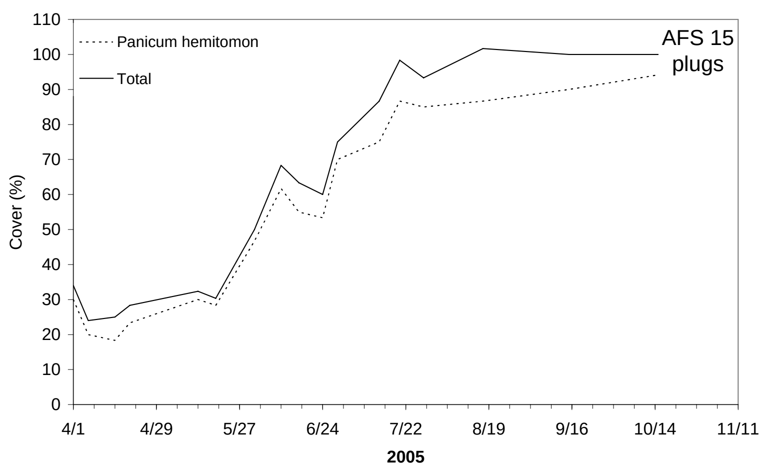
Artificial Floating Structure 14

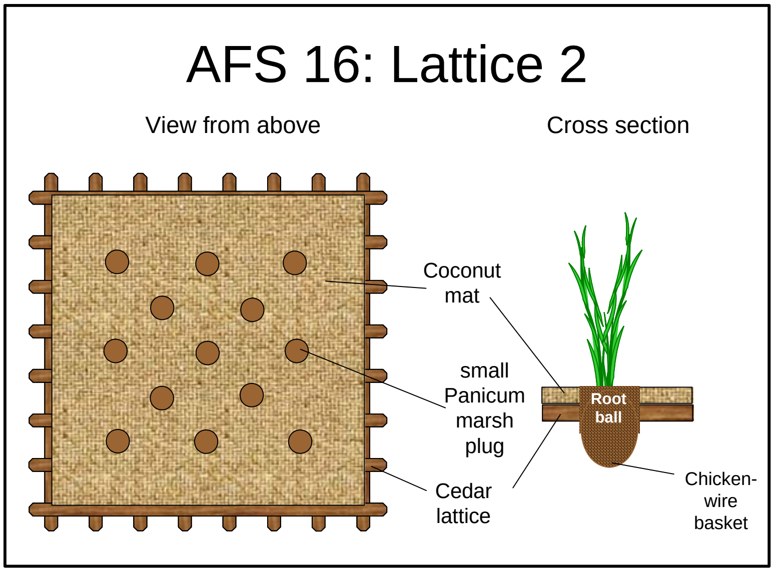
This design uses a PVC frame with a chicken-wire hammock. The frame supports 6 small burlap bags filled with a mixture of peat, bagasse, and *P. hemitomon* rhizome fragments. This design is remained unfenced. Due to grazing pressure P. hemitomon never became established on these structures, even though they maintained buoyant through the growing season.

Artificial Floating Structure 15



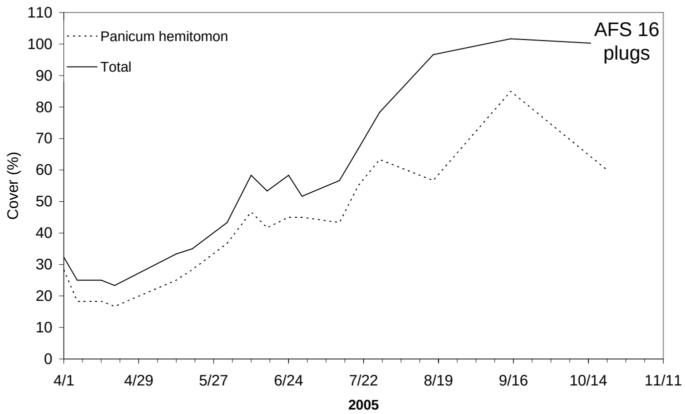
This design uses a lattice of cedar planks. Thirteen marsh plugs are suspended in chicken-wire baskets in the lattice openings. To provide a medium for lateral root spread, a coconut blanket is stapled to the bottom of the lattice. This design includes a fence. Bamboo was added to increase buoyancy after these structures submerged in early May. Average *P. hemitomon* cover was 30% on April 1, 2005, and increased to 95% by the end of the 2005 growing season. This increase was despite the submergence of some of the structures.



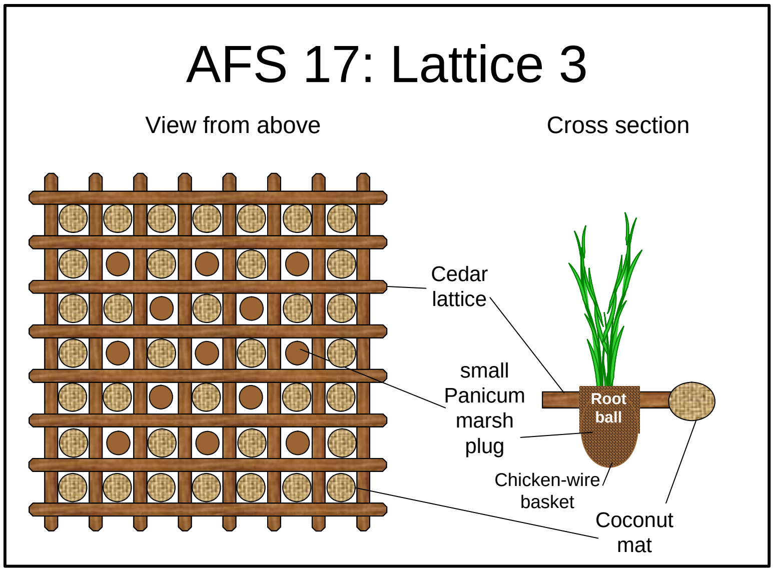


Artificial Floating Structure 16

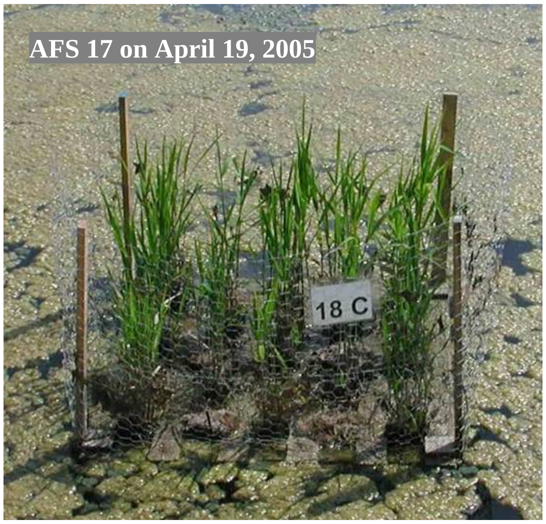
This design uses a lattice of cedar planks. Thirteen marsh plugs are suspended in chicken-wire baskets in the lattice openings. To provide a medium for lateral root spread, a coconut blanket is stapled to the top of the lattice. This design includes a fence. Bamboo was added to increase buoyancy after these structures submerged in early May. Average *P. hemitomon* cover was 28% on April 1, 2005, and increased to 75% on September 15, 2005. This increase was despite the submergence of some of the structures in July.

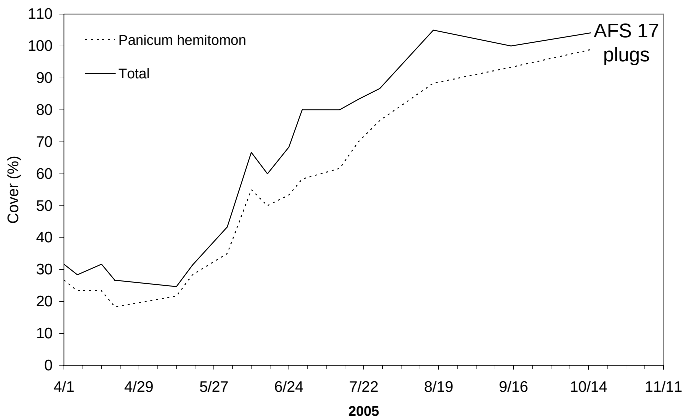


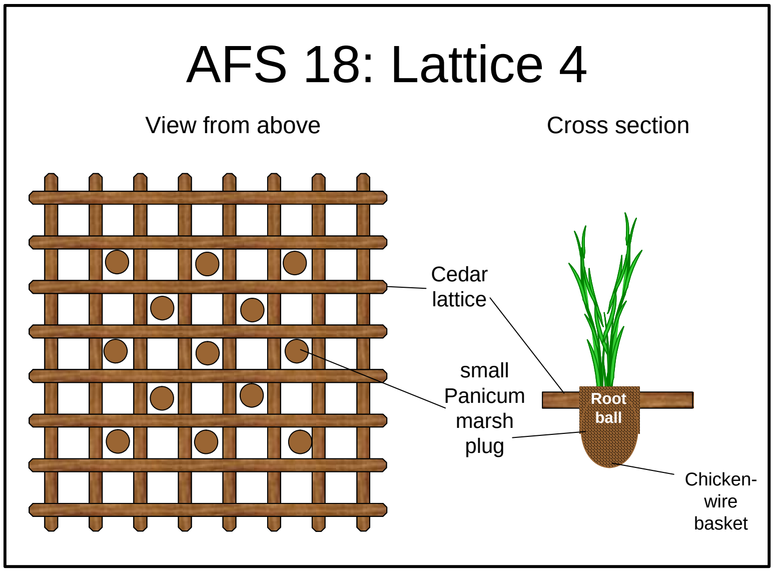
Artificial Floating Structure 17



This design uses a lattice of cedar planks. Thirteen marsh plugs are suspended in chicken-wire baskets in the lattice openings. To provide a medium for lateral root spread pieces of coconut mat are stuffed in the remaining lattice openings. This design includes a fence. Bamboo was added to increase buoyancy after these structures submerged in early May. Average *P. hemitomon* cover was 27% on April 1, 2005, and increased to 100% and the end of the 2005 growing season. All of these structures lost full buoyancy in July. Note: These structures were accidentally labeled as 18 in the field.



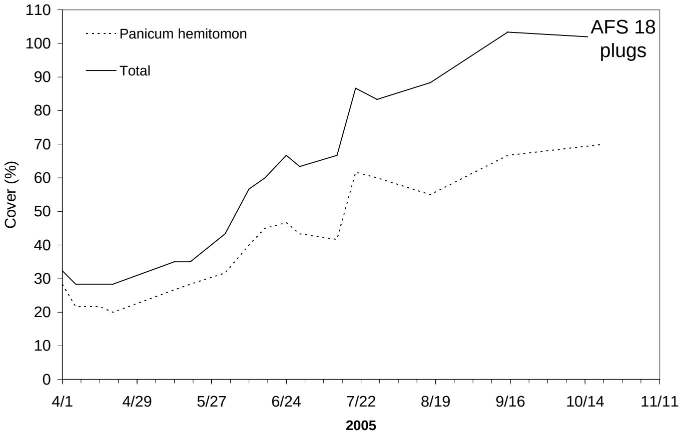




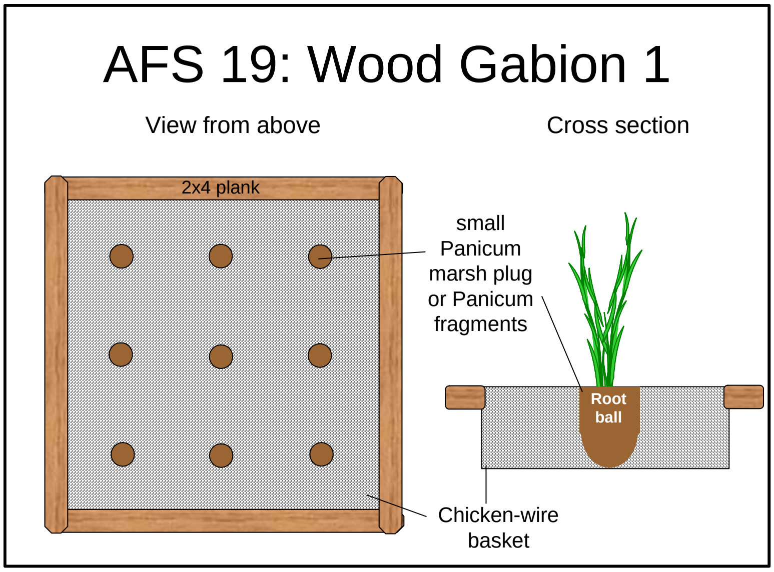
Artificial Floating Structure 18

This design uses a lattice of cedar planks. Thirteen marsh plugs are suspended in chicken-wire baskets in the lattice openings. This design includes a fence. Bamboo was added to increase buoyancy after these structures submerged in early May.

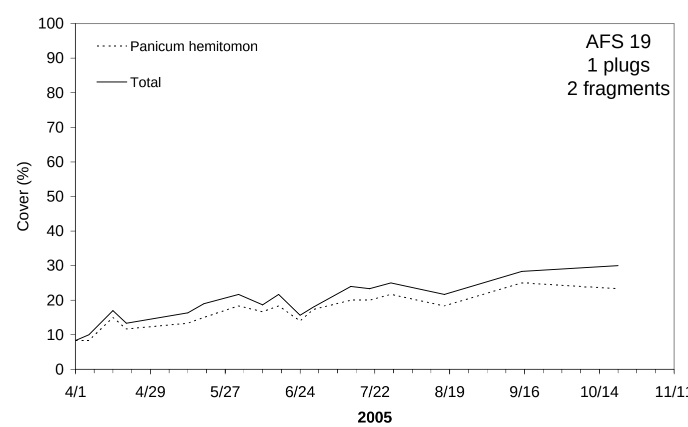
Average *P. hemitomon* cover was 28% on April 1, 2005, and increased to 70% by the end of the 2005 growing season. Several of these structures lost full buoyancy in July. Note: These structures were accidentally labeled as 17 in the field.



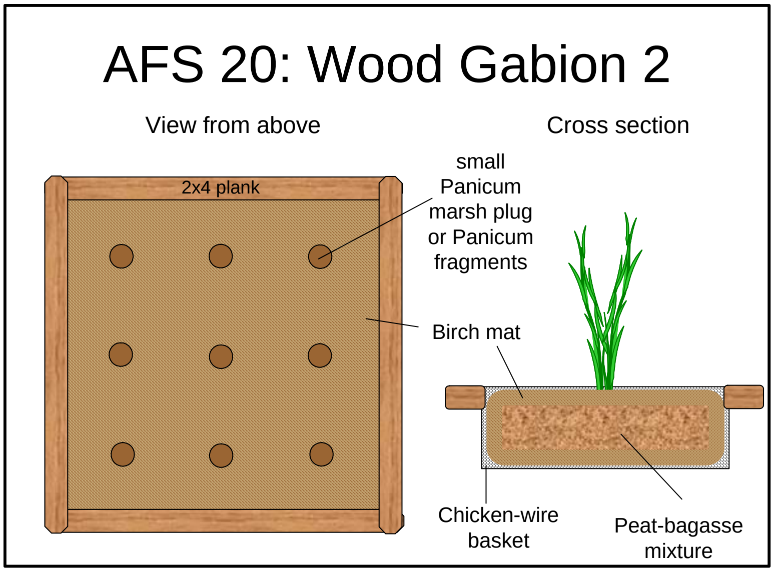
Artificial Floating Structure 19



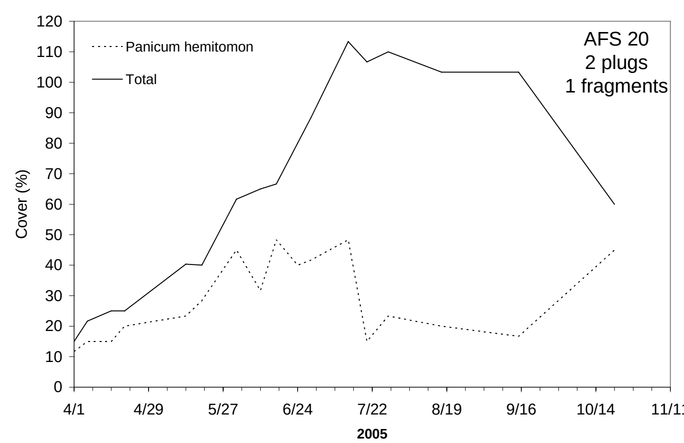
This design uses a wood frame with a gabion basket. The basket is used to support hydroponic plant growth. This design includes a fence. One of these structures was planted with marsh plugs and the other two were planted with *P. hemitomon* fragments. This design submerged in mid April and bamboo was added to get the structures to float at the surface. However, submerging of these structures continued through the growing season. Average *P. hemitomon* cover was 8% on April 1, 2005, and increased to a maximum of 25% by September 16, 2005. There was a substantial difference between the plug planted structure and the two fragment planted structures. The fragment planted structures only reached an average cover of 12% while the plug planted structure reached 50% *P. hemitomon* cover.



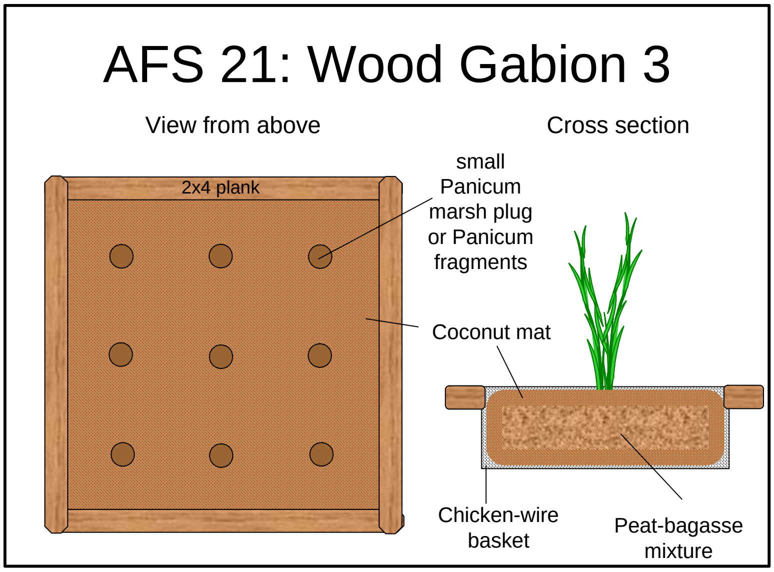
Artificial Floating Structure 20



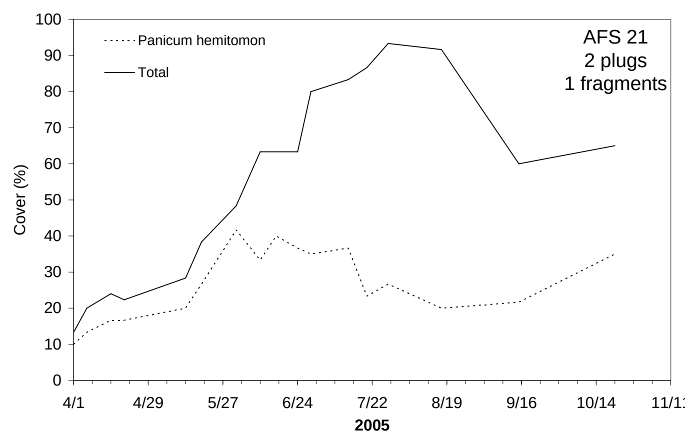
This design uses a wood frame with a gabion basket. The basket is filled with a birch mat topped by a peat and bagasse mixture topped by another birch mattress. Two structures were planted with marsh plugs and one structure with *P. hemitomon* fragments. This design includes a fence. Bamboo was added to this design in March to provide sufficient buoyancy. Average *P. hemitomon* cover was 12% on April 1, 2005, and increased to 48% by July 13, 2005. Growth of *Ludwigia* sp. in these structures was rapid and began overtopping *P. hemitomon* in July. The weight and uneven distribution of *Ludwigia* also contributed to the submergence of these structures in July and the overturning of one of these structures during Hurricane Katrina.

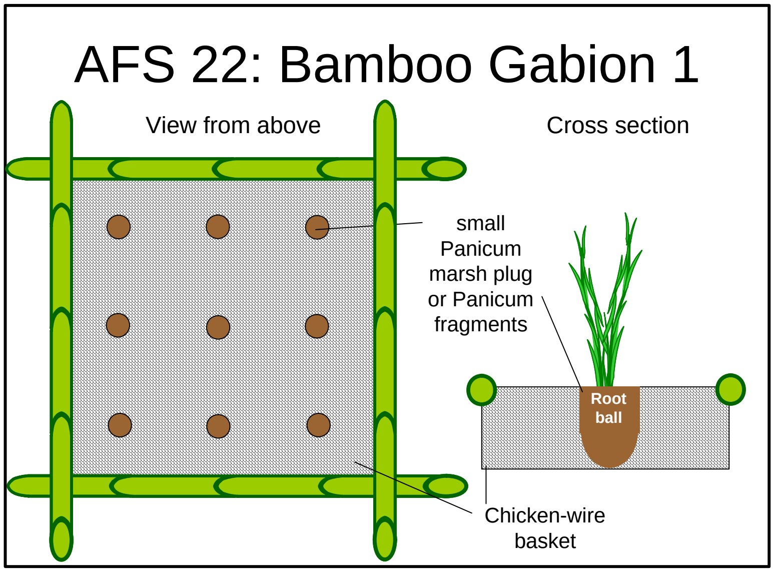


Artificial Floating Structure 21



This design uses a wood frame with a gabion basket. The basket is filled with a coconut mat topped by a peat and bagasse mixture topped by another coconut mattress. Two structures were planted with marsh plugs and one structure with *P. hemitomon* fragments. This design includes a fence. Bamboo was added to this design in March to provide sufficient buoyancy. Average *P. hemitomon* cover was 10% on April 1, 2005, and increased to 42% by June 1, 2005. In July, *P. hemitomon* cover slowly decreased due to competition with *Ludwigia* sp. The weight and uneven distribution of *Ludwigia* also contributed to the submergence of these structures in July.



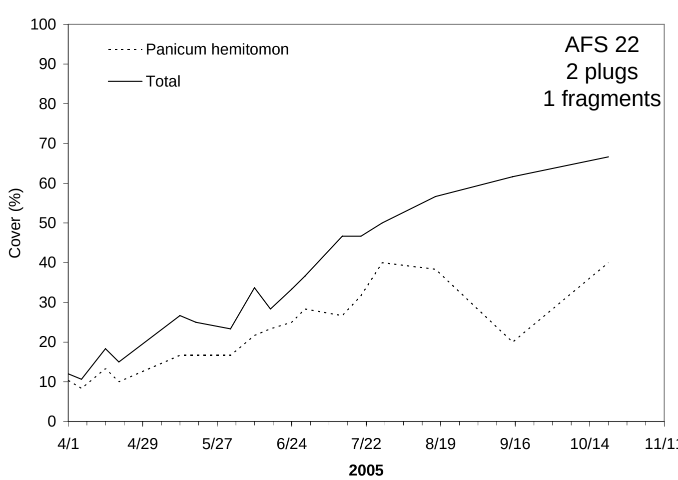


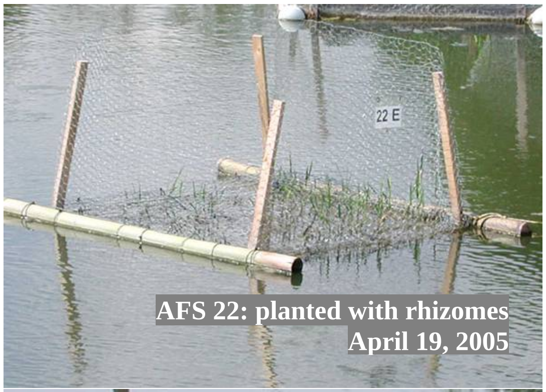
Artificial Floating Structure 22

This design uses a bamboo frame with a gabion basket. The basket supports hydroponic plant growth. This design includes a fence. Average *P. hemitomon* cover was 10% on April 1, 2005 for those structures planted with marsh plugs or plant fragments in March. P. hemitomon reached the highest cover of 40% at the end of July. Other species mainly sedges added additional cover later in the growing season.

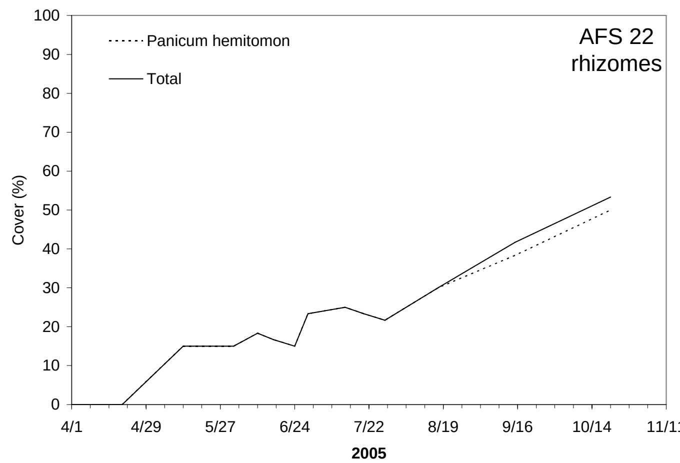
AFS 22 planted with plugs on April 19, 2005

AFS 22 planted with plugs on August 22, 2005

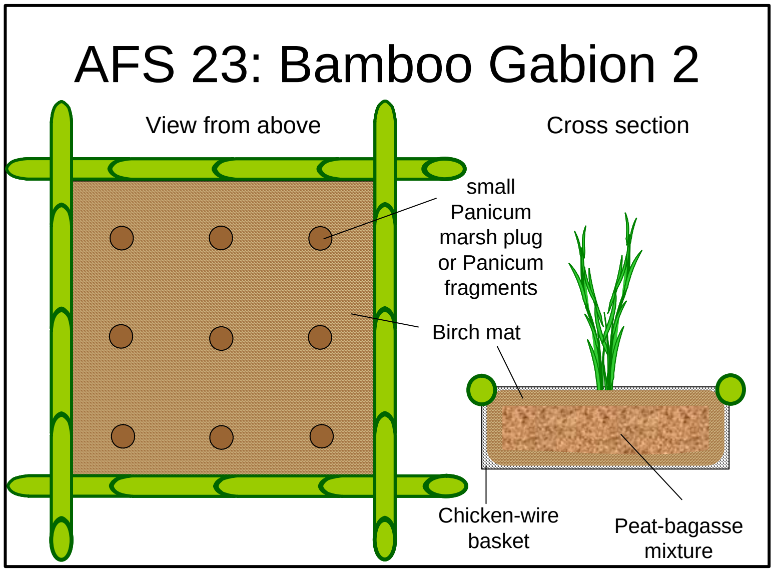




In mid-April, we added 3 replicates planted with stem fragments only and 3 replicates with rhizome fragments only. The rhizome fragments sprouted within 5 days and had an average cover of 2%. The *P. hemitomon* cover kept increasing in these structures and reached 40% at the end of the growing season.



In contrast, none of the structures planted with stem fragments showed sprouting within the first 5 days. Although a few sprouts appeared, growth in the stem planted structures was very limited.

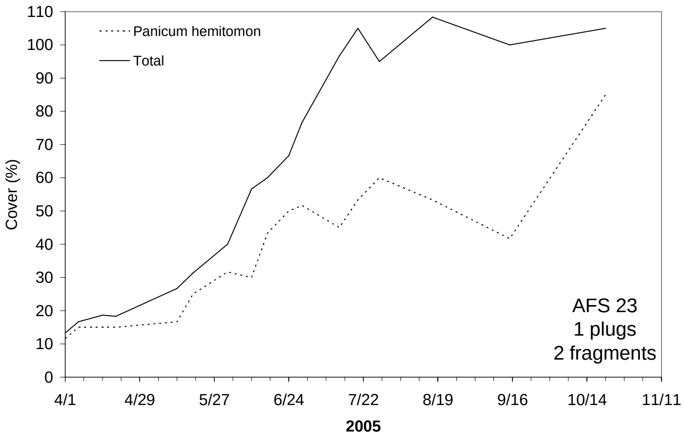


Artificial Floating Structure 23

This design uses a bamboo frame with a gabion basket. The basket is filled with a birch mat topped by a peat and bagasse mixture topped by another birch mattress. This design includes a fence. Average *P. hemitomon* cover was 12% on April 1, 2005, this increased to 85% at the end of the growing season. Although *Ludwigia* sp. appeared in the plug planted structure, no significant submergence occurred until very late in the growing season.

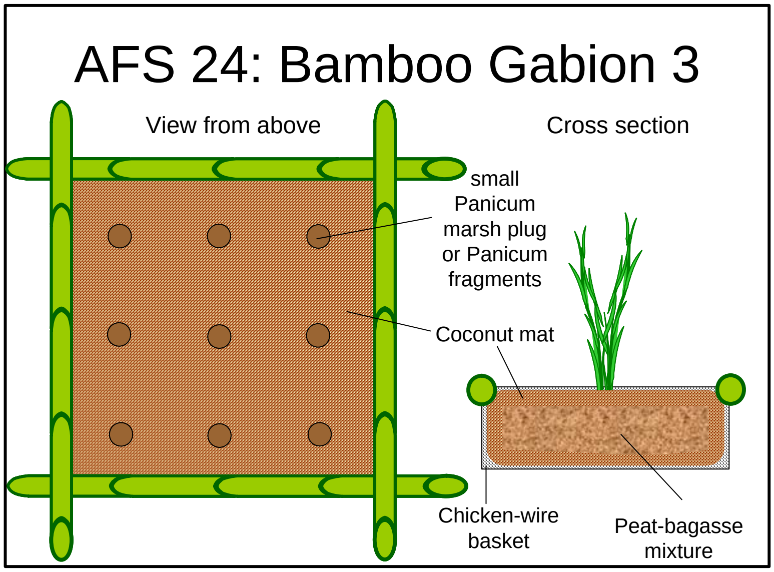
AFS 23 planted with fragments
April 19, 2005

AFS 23 planted with fragments
August 22, 2005



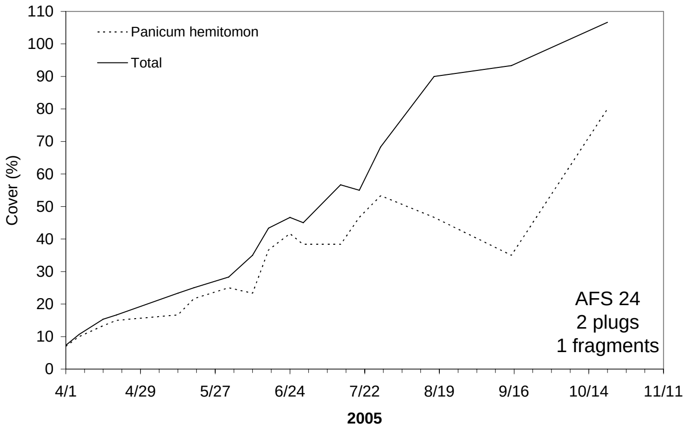
Artificial Floating Structure 24

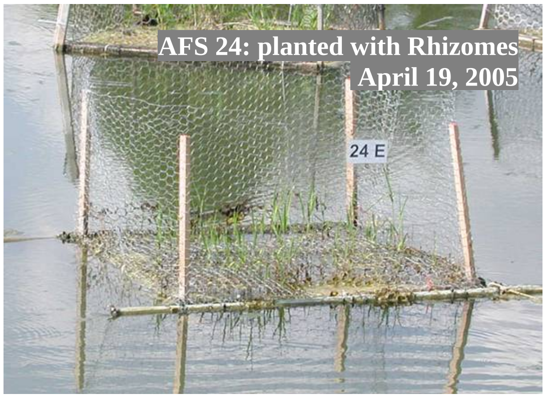
This design uses a bamboo frame with a gabion basket. The basket is filled with a coconut mat topped by a peat and bagasse mixture topped by another coconut mattress. This design includes a fence. Average *P. hemitomon* cover was 15% on April 1, 2005 for those structures planted with marsh plugs or plant fragments in March. By the end of the growing season *P. hemitomon* cover had increased to 80%.



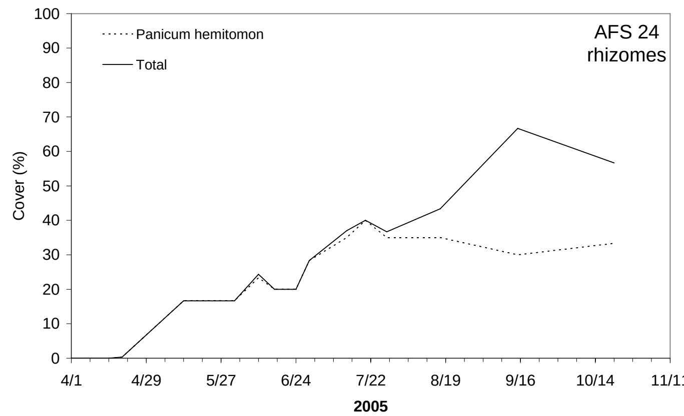
AFS 24 planted with fragments
April 19, 2005

AFS 24 planted with fragments
August 22, 2005

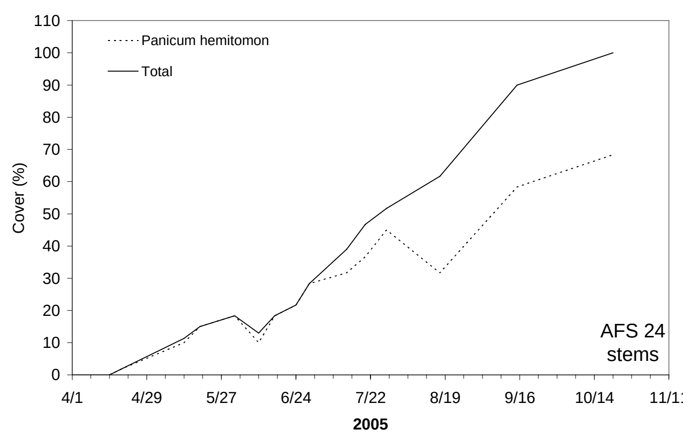


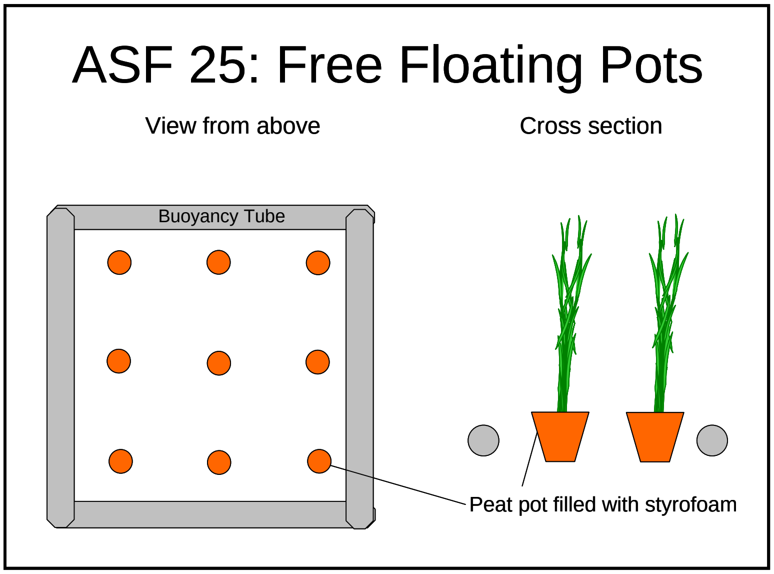


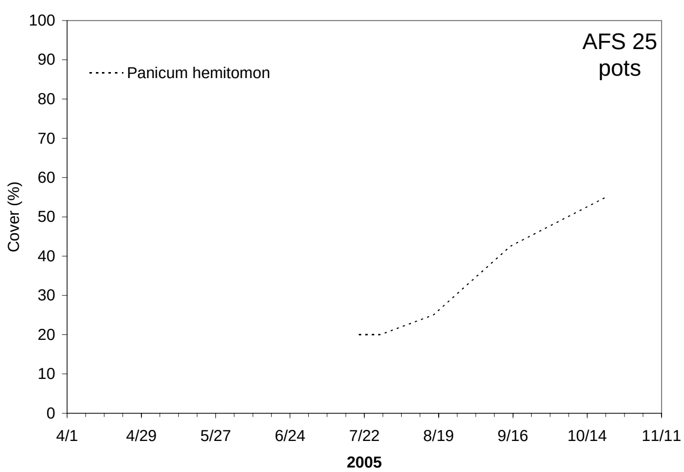
In mid-April, we added 3 replicates planted with stem fragments only and 3 replicates with rhizome fragments only. The rhizome fragments sprouted within 5 days and had an average cover of 2%. *P. hemitomon* cover in creased to a maximum of 40% in mid-July, when *P. hemitomon* cover stabilized and other species such as *Leersia oryzoides* and *Scirpus cubensis increased in cover*.



Only one of the structures planted with stem fragments showed sprouting within the first 5 days. However within the next week all structures had sprouts and *P. hemitomon* cover soon was larger in the stem planted structures than in the rhizome planted structures. End-of-growing season cover for *P. hemitomon* was 68%.





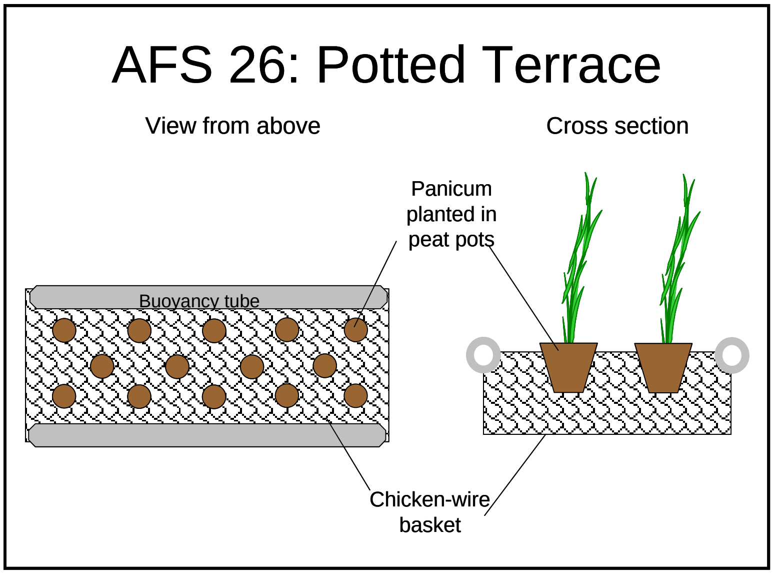


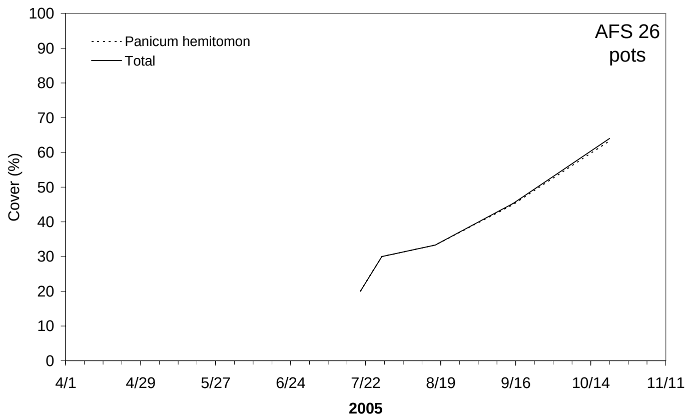
Artificial Floating Structure 25

This design uses a PVC frame that contains free floating peat pots filled with styrofoam. The purpose of the PVC frame is to keep the pots corralled and to support a fence. These structures were deployed in late July 2005, with an average *P. hemitomon* cover of 20%. By the end of the growing season *P. hemitomon* cover had increased to 55%.

Artificial Floating Structure 26

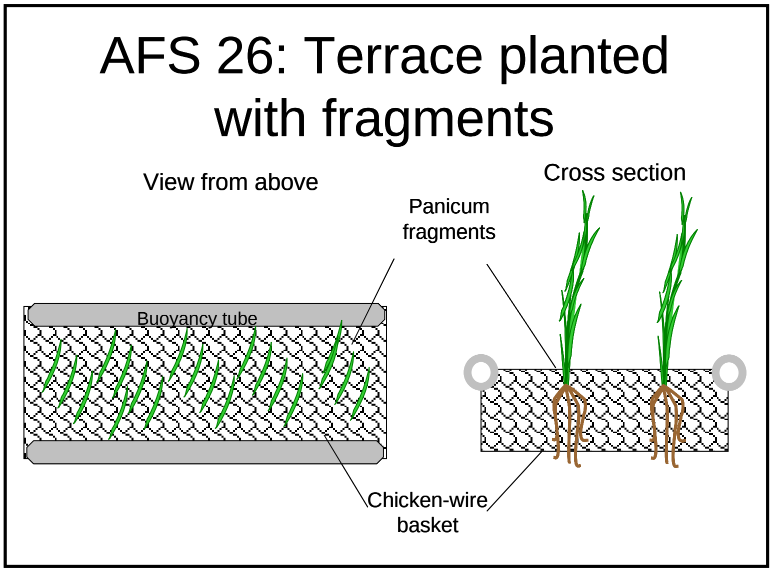
This design uses a PVC frame that supports a chicken-wire basket. Peat pots planted with *P. hemitomon* are placed in slits in the top of the wire basket. This design includes a fence. These structures were deployed in late July 2005, with an average *P. hemitomon* cover of 20%. By the end of the growing season *P. hemitomon* cover had increased to 63%.





Artificial Floating Structure 27

This design uses a PVC frame that supports a chicken-wire basket. Fragments of *P. hemitomon* are placed in slits in the top of the wire basket. This design includes a fence. These structures were deployed in late July 2005, within a week the average *P. hemitomon* cover reached 20%. By the end of the growing season *P. hemitomon* cover had increased to 80%.



AFS 27 on August 22, 2005